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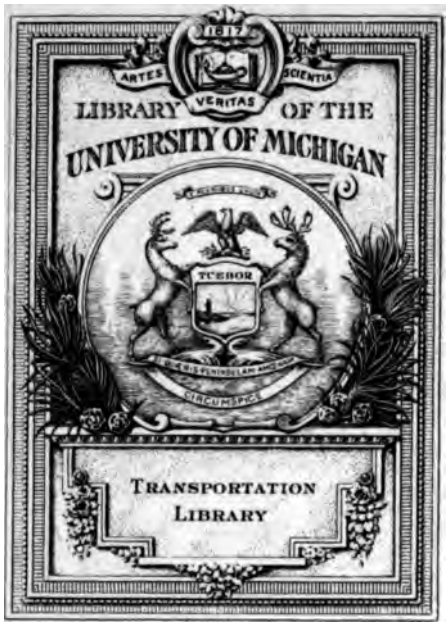
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VICTORIA BRIDGE
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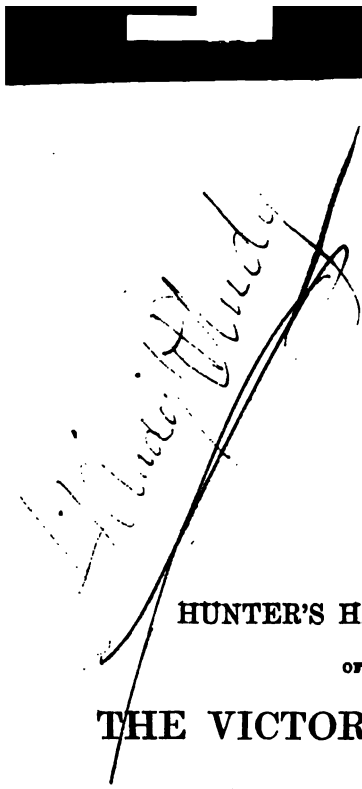
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HUNTER'S HAND BOOK

OF

THE VICTORIA BRIDGE.









ENTRANCE TO THE VICTORIA BRIDGE.

The inscription on the lintel over the entrance to the abutment is shewn in the above wood-cut; and on the lintel over the entrance to the tube is inscribed,—

BUILT
BY
JAMES HODGES,
FOR
SIR SAMUEL MORTON PETO, BART.,
THOMAS BRASSEY, AND EDWARD LADD BETTS,
CONTRACTORS.

UNIV.
OF

HUNTER'S HAND BOOK

OF THE

VICTORIA BRIDGE,

ILLUSTRATED WITH WOOD-CUTS:

A BRIEF HISTORY OF THAT WONDERFUL WORK, FROM THE TIME THAT THE FIRST PRACTICAL IDEA FOR ITS CONSTRUCTION WAS SUBMITTED TO THE PUBLIC IN 1846, UP TO ITS COMPLETION IN 1859.

ALSO,

A SHORT SKETCH OF THE LIVES

OF THE

CELEBRATED STEPHENSONS.

"Now we can form an estimate of the value of those *few acres of snow* ceded to England with such culpable carelessness by the Government of Louis XV."—*Count Jaubert at the Paris Universal Exhibition in* 1855.

BY F. N. BOXER,
ARCHITECT AND CIVIL ENGINEER.

Dedicated (by permission) to the Grand Trunk Railway of Canada.

MONTREAL:
PUBLISHED BY HUNTER AND RICKUP.
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1860.





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PREFACE.

In endeavouring to place before the reader a short, but faithful, history of the Victoria Bridge, from the time that the first practicable idea for its construction was brought before the public in 1846, up to its complete realization in 1859, the writer of these pages has sought for no information but such as he could obtain from authentic sources; and, however imperfectly the facts obtained have been compiled, he trusts that the work will be entitled to, at least, the merit of being considered a faithful record of the ways and means by which the noblest river in the world has been spanned by the noblest bridge.



DEDICATION.

THE Publishers, in dedicating this volume to the President, Directors, and Manager of the Grand Trunk Railway Company of Canada, under the favor of their permission, trust that its contents will be found to be a faithful record of events connected with its history which occurred before and during the construction of the Victoria Bridge. They have endeavored to obtain an impartial statement of facts from authentic documents, and have recorded them in its pages with feelings totally unprejudiced towards any party.

In putting together the facts connected with its history, one cannot but read with wonder of the rapid strides which this noble colony has made in civilization and in wealth, as well as in general progress in Agriculture, Manufactures, Arts, and Sciences, since the construction of its great railways, which have been truly said, to be the arteries and veins of the body politic, through which flow the agricultural productions and the commercial supplies which are the life-blood of a state; and one feels that if such has been the rapid progress of Canada, during the infancy of her days, from the construction of the Grand Trunk Railway, what will be the profit of that Railway when, in maturer years, all her resources are developed?



HUNTER'S HAND BOOK

OF

THE VICTORIA BRIDGE.

CANADA, "the brightest jewel in the British Crown," and gifted by nature so bounteously with great natural advantages; Canada,—now so justly proud of her prosperity, because that prosperity has been nobly earned by the energy and industry of an intellectual race,—but a quarter of a century past, was not considered by other nations as a commercial country, and but little known, we regret to say, to the mother country herself, except as a mere timber depôt, a large unprofitable waste, a drain upon her resources. But the elements for making Canada a great and powerful country existed among her people and in her soil, which required but some motive power to call them into action; and at the London and Paris Exhibitions, in 1851 and 1855, she took her place among the producing nations of the earth, and has since surpassed them all in the magnitude of an undertaking which now strides across our unrivalled river—a monument of engineering skill—a noble testimony of the energy and perseverance of her people—and a type of the character of the present Canadian race.

In 1759, the brave Wolfe and Montcalm fell fighting at the head of their respective armies in a deadly struggle for this Province, which, in 1760, was surrendered to the English nation; and at that time, the whole population of

the country, from east to west, did not exceed 70,000 souls.

In August, 1860—just 100 years after—we look forward with hope to behold the child of our beloved Sovereign, the heir of England's throne. He comes among us that he may behold this rich and flourishing Colony, to mingle with its industrious and happy people,—a race of whom England may well be proud; not men whose wealth has descended to them from one generation to another, nor who have gained their positions in life by the aid of powerful connections or influential friends, but men who have raised this Colony to its present position among nations by the general energy of their characters, the industry of their habits, their morality and order. If such a people constituted the inhabitants of some of the states of Europe, over which the rays of science have beamed for centuries—when on this country its light has only begun to dawn—that country would speedily become a first-rate power; and it requires but little of the spirit of prophecy to foretell that, if we are but true to ourselves, our destiny is a great one; what we have already shown to the world is but the shadow of our future greatness.

Canada is a country of unlimited resources, rich in soil and in minerals; her forests alone are a mine of wealth, and her rivers and inland seas abound with fish. These resources which are gradually becoming more developed through the easy means of transport afforded by our railways and canals, will ever be a source of a large revenue to her exchequer; and if her progress continues in ratio with her advancement during the last ten years, she will not only be known as the brightest gem in England's Crown, but will prove a faithful friend in the days of peace—a powerful ally in a *day of need.*

In 1808 not a steamer floated on the bosom of the St.

Lawrence; now hundreds rush along its waters on one uninterrupted inland navigation nearly 2000 miles in length.

In 1840, a small railroad, the only one in either Province, was that from Laprairie to St. Johns, 14 miles in length, and connecting Lake Champlain and the St. Lawrence: it was looked upon with admiration and wonder. Now, 1200 miles of railway intersect this Province in one continued line from Port Sarnia, on the shores of Lake Huron, to Rivière du Loup, near the mouth of the St. Lawrence, and, altogether, nearly 2000 miles of railroad, in different directions, have opened up the country to commerce. But thirteen years ago heavy goods had to be transported over almost impassable roads at an enormous cost and loss of time; now splendid canals connect river and lake in, almost, one continued chain of uninterrupted navigation.

In 1842, it took days for a letter to reach a distant part of the Province; at present, telegram wires, like spiders' threads, extend from city to city and the thoughts of man fly with lightning speed. The voice of our Queen has already passed under the waters of ocean in friendly greeting to a ruler of a powerful country; and we hope, with that prophetic hope which falls upon us like a forerunner of certainty, that the day is not far distant when the words of our beloved Sovereign will again pass under the great Atlantic, and bring greetings of peace, good will and gladness to her loyal subjects in Canada.

And such are the changes which have come over this Province within the short period of a quarter of a century, in which her struggles to keep pace with other countries in the rapid strides of improvement have been of no ordinary kind. There is nothing that proves more prejudicial to public undertakings than popular and false prejudices; and too frequently do we find statesmen and influential persons biassed in their opinions and judgments.



There exists, also, in every community, a certain class of people who are always ready to decry the praiseworthy projects of others, and who can view no public undertaking without attributing to its projectors selfish and sordid views; who, when success has crowned the persevering efforts of a talented man, are ready, like harpies, to snatch from him the meed of praise by attributing the glory of the work to other people.

It might be considered out of place in a work of this kind, professing to give merely a history of the bridge, to enter into any reflections of the foregoing nature, but it is our desire to place before the public, in a true light, the names of those persons to whom "Canada and the world are indebted for the Victoria Bridge," from the construction of which a new era in the commercial prosperity of this country is likely to ensue.

We also purpose to record the names of all those who were particularly employed on the work; and we would beg to remark, that in so doing, the information afforded is not from mere *hearsay*, but from a diligent and careful examination of documents, the authenticity of which is undisputed.

It has been stated that, some years ago, the idea of crossing the St. Lawrence, either by bridge or tunnel, had occurred to the imagination of some of the citizens of Montreal; in this there was nothing extraordinary, for such an idea is but a simple thought that would rise up in the mind of any ordinary man, who wished to send or bring goods across the river at a time when it was impassable from floating ice; and some very visionary schemes are said to have floated in the brains of more than one individual in this city. But to the mind of the great Stephenson, when he first visited this country, some twenty-seven years ago, "the idea of bridging the St. Lawrence

never occurred;" simply, we suppose, because he possessed no property on either shore that would have been improved by its construction in any particular spot, and then he, probably, would have wished, like other men, to have crossed the river—but by a feasible plan.

In June, 1846, an editorial appeared in the *Economist*, a paper then published in Montreal, of which the following is an extract. It was written at a time when a great difference of opinion existed as to the proper site for the terminus of the Atlantic and St. Lawrence Railway:

"But where is the terminus of the St. Lawrence railway to be? Let us examine the advantages of the several points that present themselves for the terminus; if it is made at Longueuil, or if it is placed immediately opposite the city, a little above St. Helen's Island, long solid wharfs, (owing to the shallowness of the water,) will have to be built to enable freight cars to reach vessels coming from the interior. Ferry boats will be required to convey passengers across the river, and a natural consequence must be, that a great portion of the business will be done on the opposite shore. But a still greater objection is, that at the very time we most require a railroad to carry off what produce may be left on board for shipment, all communication is closed—we mean in the spring and fall. How, then, is the difficulty to be got over? We reply, by building a bridge across the St. Lawrence. This is no visionary scheme; we speak advisedly when we say that it is *perfectly practicable*. Such a bridge should be erected from this side, a little below Nun's Island, at which part of the river the water is quite shallow, and the shoving is nothing like so violent as lower down the river."

This article was written by the Hon. John Young; and it is worthy of remark how excellent are the perceptive faculties of this energetic citizen, that the bridge has actually been constructed on, or near, the line indicated by him in the above extract.

In September of the same year, another article appeared



in the *Economist*, written by the same gentleman, in which he stated:

"Twenty years ago, the project of a bridge across the St. Lawrence would have been scouted as absurd and impracticable; nay, twenty months ago there were few, even amongst our most energetic and enterprising citizens, who bestowed a thought on the subject. The opinion is daily gaining ground that the project is not only feasible, but highly expedient for the interests of the city."

In consequence of these remarks, action was at length taken in the matter.

On the 23d September, 1846, the following resolution was passed at a meeting of the Directors of the Atlantic and St. Lawrence Railroad Company:

"It was moved by Mr. Young, seconded by Mr. Galt, 'That this Board do hereby authorize the Company's Chief Engineer to cause a survey to be made of the proposed bridge across the St. Lawrence, for the purpose of ascertaining its practicability and an approximate estimate thereof."

The first survey ever made for the site of the Bridge was by Mr. A. C. Morton, then Chief Engineer of the St. Lawrence and Atlantic Railroad, in accordance with the instructions furnished to him by the Hon. John Young. This gentleman reported on the practicability of constructing a bridge across the St. Lawrence from below Nun's Island, in the general direction of the "Tobacco House," which is nearly the line of its present site; and Mr. Gay, in his report to the Hon. John Young, Chairman of the Committee for procuring plans, estimates, &c., for a bridge across the St. Lawrence at Montreal, thus alludes to this survey:

"Another line has been examined across the river, under the direction of Mr. Morton, Chief Engineer of the Atlantic and St. Lawrence Railway, to whose kindness I am under obligations for a copy of the soundings taken upon it, which is the

more valuable as affording comparative evidence of the accuracy of our measurements."

It does not appear that Mr. Morton's report was ever published, but his plan still exists in the Grand Trunk Railway Office, and is deposited among those connected with the St. Lawrence and Atlantic Railroad Company, before it became a part of the Grand Trunk Railway. The credit, therefore, would appear to be due to Mr. Morton as having been the first Engineer who, after a survey of the river, reported favourably on the practicability of constructing a bridge across the St. Lawrence, near its present site, according to the views of Mr. Young.

In October, 1846, Mr. Gay, of Pennsylvania, was employed by a committee of citizens, consisting of Messrs. Davidson, Bourret, Hayes, Pierce, Stephens, Young, and Judah. Of this Committee, the Hon. John Young was Chairman.

Mr. Gay, who was then Chief Engineer of the St. Lawrence and Atlantic Railway, likewise reported on the practicability of constructing a bridge over the river, but he condemned what was called the "railway line," not as impracticable, but because he considered preferable (for reasons given in his Report) a line extending "from a point half a mile above the foot of the island (Nun's), across the main channel to the house occupied by Charles Mayo," on the south shore of the river. There has existed an erroneous impression that Mr. Gay reported altogether unfavourably on the practicability of constructing a bridge across the St. Lawrence. This is an error, for in his Report he distinctly states:—"I am of opinion that a permanent and substantial bridge can be built, without encountering any difficulty of a serious character." The description of structure proposed by this Engineer, was "Burr's combined truss and arch bridge."



About this time a period of general depression seems to have prevailed throughout the Province. We quote the words of an article which appeared in the Toronto *Leader* on this subject, and from which we will take the liberty of drawing largely in these pages, as the statistics contained therein were obtained from the first authority.

"Five years, however, passed away, an epoch of social and commercial depression, and of political agitation, marked by the one melancholy feature of a continual struggle for the majority even to live. What energy, Montreal, as a commercial community possessed, was absorbed in the effort to finish the railway, and out of Montreal, the bridge was not looked upon with favour."

Still the bridge was not lost sight of: on the contrary, Mr. Young seldom failed, at the annual meetings of the St. Lawrence and Atlantic Railway Company, to point out its imperative necessity. It was not, however, till June, 1851, that the Directors of the above Company of which Mr. Young was one, furnished Mr. Thos. C. Keefer, C. E., with instructions to make a survey of the bridge. Mr. Keefer had been employed by the Montreal and Kingston Railway Company, of which Mr. Young was President, to make a survey of a line of railway from Montreal to Kingston, and it was at Mr. Young's earnest request to the Directors of the above Company, that the survey of the Bridge was included. It is worthy of being recorded in these pages, that Mr. Young overcame the great obstacle to Mr. Keefer's survey of the Bridge, by becoming responsible for the sum of £1500, advanced by the St. Lawrence and Atlantic Railway Company. This sum however, was insufficient, and the Harbour Commissioners advanced £150 as well, on Mr. Young's *personal guarantee.* The amount due to the St. Lawrence Railroad, was paid by the Grand Trunk Railway Company after the pass-

ing of the Bill; and the amount due to the Harbour Commissioners, with the advances made by Mr. Young out of his *private funds*, amounting to upwards of £600, were paid by the Grand Trunk Railway Company, about three years ago, under the authority of an Act of Parliament, which provided for the payment of all just claims against the St. Lawrence and Atlantic Railway Company.

It is seldom, indeed, that we meet with such liberality, in this country, on the part of a private individual to forward public purposes; and this, alone, shews the confidence Mr. Young possessed in the scheme, and entitles him, with what has been already stated, to the honour of having been the first projector of the Victoria Bridge.

In September, 1852, Mr. Young, then acting as Chief Commissioner of Public Works, suggested to the Hon. L. H. Holton, then President of the Montreal and Kingston Railway Company, the propriety of that Company waiving their charter, upon condition that the Grand Trunk Company would construct the Victoria Bridge. This was done in a letter dated 16th September, 1852.

The result of Mr. Keefer's survey is contained in a very ably written Report, which was afterwards published in 1853; and in justice to that gentleman, we cannot refrain from laying before the reader a few short extracts.

Mr. Keefer, in commencing the survey, at once saw the necessity of a thorough hydrographic survey of the shoals opposite to Montreal; which was very precisely made on the ice. The result of these soundings, Mr. Keefer states, "has fully confirmed my anticipations with respect to the peculiar conformation of the bed of the St. Lawrence opposite to Montreal, and its remarkable adaptation for a bridge site." He then proceeds to state that the bridge must be so arranged as not to impede the navigation, that a draw-bridge in its centre of 200 feet in width was im-

practicable, and recommended the adoption of a high level bridge, elevated about 45 ft. over low water mark at the abutments, and rising gradually, from either shore, to the height required for steamers to pass under its main arch, which was to span the navigable channel. The bays, or distances between the piers, on account of the cribs which were to be placed around them as ice breakers, he fixed at 250 feet, and recommended the importance of solid approaches upon the shoals at either end of the bridge (as at present constructed).

"Having stated, first, that the bridge should pass over the navigation—second, that it should be a solid railroad bridge resting upon piers, and, thirdly, that these piers should be as few in number as practicable, I will add that it is greatly to be desired that so extensive and important a structure should be constructed of some more durable and less inflammable a material than wood; the length of the superstructure required is about 7000 feet, the cost of which, if constructed of iron, would be about six times greater per lineal foot than that built of wood."

"The extra cost of iron over wood would be about £500,000, or much more than the whole estimate for a wooden bridge. A wooden bridge properly constructed and protected will last half a century, and if it were not for the contingency of fire, would be all that is needed."

The difficulty of obtaining money for public works at this time—even for the means required to carry on this survey—may have influenced Mr. Keefer's mind in making this Report, as economy in every shape had to be consulted—for, in another part of Mr. Keefer's Report, he says:—

"The cost of bridging the St. Lawrence from Point St. Charles across Moffatt's Island to the St. Lambert shore, will of course depend upon the plan and material employed; but as the financial obstacles have hitherto been the barrier to its commencement, it is necessary to present estimates, showing the least

amount for which a serviceable structure can be obtained, as well as estimates for a complete and durable work worthy of the great interests which it affects." Again; "Recognizing the principle that it is the duty of an engineer to shape his plans according to the wants and necessities of the case, it will be evident that the class of structure undertaken will be governed by the prospective revenue.

"The cost of an effective bridge upon the site proposed, with a superstructure of wood for the arches, and a wrought iron tube for the centre one, the whole resting upon abutments and piers of substantial masonry, and having approaches formed by solid embankments of earth, will be £400,000 currency. With an iron superstructure in side arches, the cost would be £900,000 currency."

From the above extract we might infer that Mr. Keefer would have recommended a superstructure entirely of iron, could he have foreseen the amount of funds that were obtained a few years afterwards for this great object. As it was, he recommended a tubular beam of iron for the centre opening, at an additional cost of £43,000.

This Report of Mr. Keefer's, which embodied all the information obtained by the two previous surveys, entered very minutely into the local phenomena of the piling of the ice, and the possibility of overcoming the physical difficulties to be encountered, and was of great service to Mr. Stephenson, who, in making allusion to a portion of the work says:—

"I cannot do better than quote the following words from the excellent report addressed to the Hon. John Young by Mr. T. C. Keefer, whose experience in such matters, from long residence in the country, entitles his opinions, as to the proper character of such works, to confidence."

It would be out of place here, to enter into the differences and difficulties that occurred before the great railway contract ultimately fell into the hands of one great firm.

In October, 1852, the Grand Trunk Railway Company



made their first location surveys for the bridge; and in February, 1853, the survey for the bridge, on its present site, was commenced.

As we have already given notice to the names of those Engineers who were connected with the preliminary surveys and designs, we feel bound to say a few words in relation to Mr. Ross's claims in regard to the *great work;* for it is much to be regretted that any unpleasant feeling of distrust and jealousy should have arisen between Mr. Ross and Mr. G. R. Stephenson, the relative of Mr. Robert Stephenson, at a time when that colossus of science—that great and good man—was passing from this life to his God.

It would appear, from all that we can ascertain on this subject, from which we have made our own deduction, and the reader has the facts before him to make his therefrom, that when Mr. Ross visited this country in 1852, Mr. Young, who never for a moment abated in his zeal to see the accomplishment of his wishes fulfilled, took Mr. Ross with him in a boat, accompanied by a third person, to examine the different localities which had been recommended for a site of a bridge by the Engineers before mentioned; and after spending some hours upon the water in a careful examination, Mr. Ross was of opinion that the present site was the one he would select, and strongly advocated the construction of an iron tubular bridge. It is thought that before Mr. Ross returned to England he prepared a design of a bridge.

That Mr. Ross put his ideas into form, and is entitled to the credit of having submitted a design for a tubular bridge across the St. Lawrence is very probable, although Mr. Stephenson does not allude to it. Mr. Stephenson, in a speech which he made at a dinner given to him by the citizens of Montreal on the 19th of August, 1853, said on that occasion:—

"I cannot sit down without referring to the all important subject of a bridge over your magnificent river. Abundance of information was brought to me in England by my esteemed friend Ross, during the late visit he paid to that country, so that I was able to get a *good notion of what the bridge was to be* before I came out here. The first idea was certainly startling. I had been here twenty years before, and the St. Lawrence seemed to me like a sea, and I certainly never thought of bridging it."

And on the same occasion he said:—

"I assure you I appreciate your kindness deeply; and one of the proudest days of my life will be that on which I was called upon to confer with the Engineers of the Grand Trunk Railway on bridging the St. Lawrence."

There is nothing in the above extracts that would lead one to suppose, for a moment, that any other party than Mr. Stephenson could lay claim to the design for the Bridge as it now stands. But, towards the completion of the work, and just previous to Mr. Stephenson's death, an unpleasant correspondence took place in some English and Canadian newspapers on this subject.

An article appeared in the London *Morning Post*, in which it was stated that "to Mr. A. Ross is due the entire credit of the plan by which it (the Bridge) has been accomplished, adding, that the position of Mr. Stephenson was a very secondary one, being employed merely "as a consulting Engineer." It also stated that "the whole design for the Bridge was completed, the estimates made, and the contract entered into before even Mr. Stephenson was spoken to on the subject, and that the form of the piers and icebreakers was due to Mr. Ross." The author, over the signature of "Veritas," claimed for Mr. Ross the whole credit for the entire plan of the Bridge, and designated that gentleman "as the man to whom Canada and the world are indebted for conceiving the design of the Victoria Bridge, providing for it, and successfully overcoming all difficulties, and carrying out the details of the plan."



To this bold assertion, put forth in a prominent English paper, Mr. George Robert Stephenson, (his cousin then lying dangerously ill,) found himself bound to reply, as silence, to such a broad assertion, would not only have left a stain upon a hitherto stainless character, of having appropriated to himself the credit of another man's design, but would have been construed into a silent acquiescence in the statement put forth.

The reply to this charge went on to say that,

"Mr. Stephenson, although he no doubt relied frequently and largely upon Mr. Ross, is by no means indebted to that gentleman, as the letter (in the *Morning Post*) would imply, even for the data on which his calculations were made. These data were chiefly collected by Mr. T. C. Keefer before Mr. Ross visited Canada, and Mr. Keefer handed over his material to Mr. Ross on leaving the service of the Company.

"All the details, from first to last, have been under Mr. Stephenson's supervision, and many of them worked out in his office in London, under my sole superintendence. The whole of the iron work has been designed in this office. It has been constructed, and some of the tubes put together temporarily in England, and it has all been shipped to Canada with detailed drawings, and instructions approved by Mr. Stephenson himself, so as to leave the parties on the other side little more than the duty of putting the pieces together as desired.

"The construction of the bridge was, from first to last, placed in the hands of Mr. Stephenson by the Railway Directors, with full power to appoint whomsoever he thought proper to assist him. The Directors had placed their reliance on his reports, and have held him responsible for the works. Mr. Stephenson would not have shrunk from the responsibility had any unforeseen failure or accident occurred, nor has he shrunk from defending both the principles and the details of his plan from the various attacks to which they have been subject.

"Allow me to add, however, that it is with great reluctance, and only as an act of justice to other parties concerned, that Mr. Stephenson authorizes me, and that I feel compelled to make this statement. Mr. Stephenson has always been, and always will be, ready to do ample justice to Mr. Ross, who has never

himself put forth the extraordinary pretensions claimed for him."

The concluding paragraph of this letter would have been quite satisfactory for public opinion on the matter, had Mr. Ross kept silent; but, in reply to Mr. G. R. Stephenson, he called upon the Hon. John Young for a statement of the facts known to him when the site of the proposed bridge was examined in July, 1852. Mr. Ross, therefore, fairly endorsed the article in the Morning Post over the signature of "Veritas;" he, moreover, designated the letter of Mr. G. Stephenson as malicious, and written without the authority of Mr. R. Stephenson. Mr. Young replied to Mr. Ross, stating, as before mentioned in these pages, that Mr. Ross had accompanied him to examine the various sites proposed for the bridge, and "when near the present site, Mr. Ross first suggested the idea of a tube or beam bridge, and exactly conveyed to my mind a description of the present structure. This was in the spring of 1852, one month after the arrival of Mr. Ross, and before it was possible for him to communicate with Mr. Stephenson."

Now it is not our desire to take one iota from the credit fairly due to Mr. Ross; on the contrary, he is entitled to the highest praise for the manner in which he performed the duties of Chief Engineer on this side of the Atlantic; but no one who has read the beautiful Report of Mr. Stephenson (which we have printed in full in the Appendix) can for a moment suppose that any other man than he conceived, designed, and carried out the Victoria Bridge in its present form. He had too many laurels on his brow, to seek, for one single moment, to detract from the fair fame of any man; and his name stands too high for any one to suppose that, if Mr. Ross was entitled to the credit of the design, he would not gladly have testified thereto.

As we said before, it is probable that Mr. Ross did make a design for a tubular bridge before Mr. Stephenson was appointed Engineer, but, if so, it must have been a very crude one. Mr. Stephenson merely said that "abundance of information was brought to me in England by my esteemed friend Ross, so that I was able to *get a good notion of what the bridge was to be* before I came out here;" but, in suggesting the form of a tubular bridge to Mr. Young, Mr. Ross was merely adopting the invention of Mr. Stephenson, which had been patented, and so successfully carried over the Menai Straits, two years before. Mr. Morton and Mr. Keefer are just as much entitled to the claim of being the first designers of the Victoria Bridge, as it now stands, as is Mr. Ross, when we take from it the merit of the tube principle, to which the last gentleman could lay no claim. Their lines, as regards the site of the bridge, are nearly identical; on any of the sites proposed by them a bridge could have been in safety constructed, and we presume that there could have been little difference in the form of the piers and the distances between them, as the cut water, or ice breaker, which now forms a part of the stone piers, was not the method first contemplated, even by Mr. Stephenson himself, as will be seen by the following extract from Mr. Stephenson's Report to the Chairman and Directors of the Grand Trunk Railway Company:

"In the first design for the Victoria Bridge, ice breakers, very similar to the above described by Mr. Keefer, were introduced, but, subsequently, the arrangement was changed, partly with a view of gaining the assistance of the whole weight of the bridge to resist the pressure of the ice before it became fixed, and partly for the purpose of obviating a considerable annual outlay."

Mr. Stephenson made no mention whatever, at the public dinner given to him at Montreal, *at which Mr. Ross was present*, of any design having been submitted to him

by that Engineer. He gives Mr. Ross full credit for all data collected by that gentleman, but says not one word of any plan having been submitted to him; and the only inference we can draw from this silence, is, that to Mr. Stephenson, alone, is due the credit for the Victoria Bridge, as it now stands, in all its details and perfection.

Mr. Ross' name was associated with that of Mr. Stephenson, in the contract entered into by the Grand Trunk Railway Company, with Messrs. Peto, Brassey, and Betts, in the same way as was Mr. Fairbairn's in the construction of the Conway Bridge; but it was more particularly necessary in this case, as Mr. Ross was to be the Chief Engineer on this side the Atlantic, and his position required to be determined and mentioned in the body of the contract, as the contractors could only be paid upon his certifying to the work having been properly performed. The contract states:—

"The contractors will make, build, and construct the said tubular bridge over the said river St. Lawrence at or near Montreal, according to the plans, sections, and specifications prepared and drawn by Robert Stephenson, of London, aforesaid, Civil Engineer, M. P., and Alexander McKenzie Ross, of Montreal, C. E."

But immediately following, it says:

"The Bridge when completed to be in perfect repair, and of the best and most substantial character, and to be approved of by the said Robert Stephenson."

Mr. Ross' name is here left out, as he was merely the Assistant Engineer.

Further on it states:

"That in the case of the death, refusal, or inability to act of the said Alex. McKenzie Ross, another engineer shall from time to time be appointed by the said Robert Stephenson in place of the said Alex. McKenzie Ross, and who shall have all the powers of the said Alex. McKenzie Ross. And in the event of the

death or refusal or inability of the said Robert Stephenson, then all things then remaining to be done by the said Robert Stephenson shall be done by an eminent Civil Engineer to be appointed by the President for the time being of the Institution of Civil Engineers in England, upon the requisiton of the parties hereto, or either of them."

Here we see again the secondary position of Mr. Ross: if Mr. Ross should die or refuse to act, Mr. Stephenson has full power to appoint another Engineer in his place; but if Mr. Stephenson should die, Mr. Ross is not to replace him, but his position to be filled up by an eminent Engineer, appointed by the President of the Institution of Civil Engineers.

In the next paragraph of the contract it states:

"That if any question or difference of opinion shall arise between the parties hereto, as to this agreement—or any matter connected therewith or arising thereout in any way, &c., it shall be referred to the absolute decision of the said Robert Stephenson, as sole arbitrator; and the decision of the said Robert Stephenson shall be binding and conclusive upon both parties as to the question or difference of opinion so referred to him."

It is the duty of every Assistant Engineer, and more particularly in the case of Mr. Ross, who was so far separated from the principal, to collect all data, and to afford such suggestions from time to time, as he may, in his professional opinion, consider advantageous to submit to the Chief Engineer, with regard to any alterations deemed necessary to the works constructing under his superintendence, and which, from his more perfect knowledge of the locality, &c., he is expected to be better informed upon than the head of the department. And no doubt Mr. Stephenson received many valuable suggestions from Mr. Ross during the progress of the work, particularly with regard to the icebreakers, piers, &c., as we find mentioned in a letter from Mr. Ross to Mr. Stephenson, dated 30th Nov., 1855.

Mr. George R. Stephenson distinctly states, in his letter dated 22d Sept., 1859:

"Mr. Ross, from his first connection with the Victoria Bridge, has been, together with the rest of the Engineering staff, under the pay of Mr. Stephenson, the Chief Engineer. Mr. Ross has not ventured at any time on any important work connected with the bridge, except upon instructions or after consultation with Mr. Stephenson, nor has Mr. Ross had to bring any originality of *conception* or *ingenuity* of adaptation to bear upon either the designs or the details since the work commenced."

As this assertion was never, to our knowledge, directly denied, we may fairly place on record in these pages the names of the following gentlemen and the merits to which they are justly entitled.

To the Hon. John Young, then, is Canada indebted for the conception of a feasible plan of a bridge across the St. Lawrence on its present site, and which would not have been constructed at the present day, had it not been for the great personal exertions, and the pecuniary assistance rendered by him to obtain the surveys. He it was who gave it its first motive action.*

Mr. Morton's name must be associated with its history, as the engineer who first reported on the practicability of constructing a bridge across the St. Lawrence, somewhere near its present site.

To Mr. Keefer was Mr. Stephenson indebted for all the valuable data collected and mentioned in Mr. Keefer's report, and this engineer is justly entitled to the full credit of having designed the first plan of a bridge over the St.

* Nor is this the only public work of importance and utility to the great commercial interests of the Province for which the people of Canada are indebted to the Hon. John Young, as is well known to his fellow citizens, though not generally so to strangers. It would be out of place, however, to allude to them in these pages.



Lawrence which could have been successfully carried into effect, as has been subsequently proved by the construction of the Victoria Bridge upon nearly the same site.

To Sir William E. Logan was Mr. Stephenson indebted for his first ideas of the probable effect of the pressure of the ice against piers.*

Mr. Ross, as Chief Engineer on this side of the Atlantic, is entitled to very great credit for his careful supervision of the work, which was accepted from the hands of the contractors on the 17th December, 1859, by the two English engineers sent out for that purpose, according to the expressed wish of Mr. Stephenson before his death, as a perfect structure, "completed satisfactorily according to the true spirit and meaning of the specification."

Mr. Hodges, as the Agent and Chief Engineer for the contractors, is entitled to unbounded praise for his untiring energy, and the skill and management with which he so successfully conducted this great and responsible undertaking, in which he was most ably assisted by the assistant engineers, C. Legge and G. Duncan.

The position of Mr. Hodges was indeed a trying one. Entrusted with the carrying out of the most important engineering work at that period constructing in the world, with a deep responsibility of failure resting upon his shoulders, with the daily superintendence of the work of up-

"* I have read and studied with pleasure the whole of the varied conditions of the river, from the commencement of the formation of the ice to its breaking up and clearing away in the Spring. To this memoir I am much indebted for a clear comprehension of the formidable tumult that takes place at different times amongst the huge masses of ice on the surface of the river, and which must strike the eye as if irresistible forces were in operation, or such as, at all events, would put all calculations at defiance.—*Stephenson's Letter to the Shareholders of the G. T. R. Co. 2d May*, 1854.

wards of 2000 men variously employed, whom he had to organise and discipline, to ensure a proper performance of their respective duties, and with a host of difficulties to encounter, monetary, engineering, and incidental, all of more or less magnitude, he required a master mind of no ordinary capacity to grapple with them, and an energy and perseverance of no ordinary character. The best tribute we can pay this gentleman is by quoting the words of the Lord Bishop of Montreal, spoken at the dinner given by Mr. Hodges on the part of the contractors, to celebrate the completion of the great work which he constructed:

"For the rest, I have only to say, that I am here to-day, not merely because I have taken a great interest in watching this gigantic work of which you have heard—in watching each pier in its erection, or in watching its multitudinous rivets which have connected the vast tubes together; not merely because I wished to join you in celebrating its opening, but because I wished to pay personal respect to Mr. Hodges, who, in after years, will be remembered with pride—remembered for his integrity, honesty, and ability, and the Christian principle with which he has endeavoured to provide for the education of the young and the spiritual supervision of all people connected with the works on which he was engaged."

But to Mr. Stephenson, alone, is due the design of the Victoria Bridge, as we now see it, in all its details, symmetry, and strength: the last monument of his fame and genius; which is likely to mock for ages the hydraulic force, and bid defiance to the glacial ramparts, of the great river over which it strides, until its materials mould away in the ocean of time, and its history is forgotten by future generations.

Having, thus, fully gone into the merits and claims of those parties whose names were connected intimately with the scientific part of the work, we must not pass over the names of two gentlemen, the Hon. John Ross and the Hon.

F. Hincks, whose exertions and political influence had much to do in carrying out our great line of national railway, and obtaining that confidence of the English people in the good faith of Canada, which has caused them to invest so much of their surplus capital in our public undertakings, and which has been attended with such beneficial results in the development of the resources of this province.

The grand scheme of a national railway, for a distance of 1200 miles, and passing through the richest parts of Canada, would still have been an imperfect undertaking, without some means of communication, at all seasons of the year, between the north and south shores of the St. Lawrence; and the whole line of the Grand Trunk Railway would have been more of a provincial undertaking, without the bridge, which was the key required to open the intercourse of the whole province to the Atlantic seaboard.

These important considerations bore with their full force upon the Directors of the Grand Trunk Railway Company, and the people of Canada felt the necessity of the undertaking.

They had now faith in the surveys and reports made as to the practicability of its construction. But the Directors of the Company, in order to gain the confidence of the English capitalists, and ascertain, beyond doubt, that a bridge could in safety be constructed, deemed it prudent, before commencing a work involving such an immense outlay, to have the advice of the most eminent engineer they could counsel, and, accordingly, decided in 1852, to obtain the services of Mr. Stephenson.

But before commencing a description of the bridge, and the difficulties to be overcome in its construction, we cannot refrain here from giving a long extract from a paper read by Sir W. E. Logan, Provincial Geologist, before the Royal Geological Society, London, the perusal of which will

well repay the reader, as it so graphically illustrates the local phenomena which take place in winter opposite to this city, by which the vast mass of ice is set in motion by the whole hydraulic force of the river and thrown up into huge piles one above the other, fifty feet in height, presenting to the eye of the beholder, a power sufficient, apparently, to crush beneath its pressure any obstacle, and tear from its base masonry of the hugest proportions:

"There is no place on the St. Lawrence where all the phenomena of the taking, packing, and shoving of the ice are so grandly displayed as in the neighbourhood of Montreal. The violence of the current is here so great, and the river in some places expands to such a width, that, whether we consider the prodigious extent of the masses moved or the force with which they are propelled, nothing can afford a more majestic spectacle or impress the mind more thoroughly with a sense of irresistible power. Standing for hours, together, upon the bank overlooking St. Mary's current, I have seen league after league of ice crushed and broken against the barrier lower down and there submerged and crammed beneath. And when we reflect that an operation similar to this occurs in several parts from Lake St. Peter upwards, it will not surprise us that the river should gradually swell.

"By the time the ice has become stationary at the foot of St. Mary's current, the waters of the St. Lawrence have usually risen several feet in the harbour of Montreal, and, as the space through which this current flows affords a deep and narrow passage for nearly the whole body of the river, it may well be imagined that when the packing here begins the inundation rapidly increases. The confined nature of this part of the channel affords a more ready resistance to the progress of the ice, while the violence of the current brings such an abundant supply and packs it with so much force, that the river, dammed up by the barrier which in many places reaches to the bottom, attains in the harbour a height usually twenty, and sometimes twenty-five feet, above its summer level; and it is not uncommon, between this point and the foot of the current, within the distance of a mile, to see a difference in elevation of several



feet, which undergoes many rapid changes, the waters ebbing or flowing according to the amount of impediment they meet with in their progress from submerged ice.

"It is at this period that the grandest movements of the ice occur. From the effect of packing and piling, and the accumulation of the snows of the season, the saturation of these with water, and the freezing of the whole into a solid body, it attains the thickness of ten to twenty feet and even more: and after it has become fixed as far as the eye can reach, a sudden rise in the water (occasioned, no doubt, in the manner mentioned) lifting up a wide expanse of the whole covering of the river so high as to free and start it from the many points of rest and resistance offered by the bottom, where it had been packed deep enough to touch it, the vast mass is set in motion by the whole hydraulic power of this gigantic stream. Proceeding onward with a truly terrific majesty, it piles up over every obstacle it encounters; and when forced into a narrow part of the channel, the lateral pressure it there exerts drives the bordage up the banks, where it sometimes accumulates to the height of forty or fifty feet. In front of the town of Montreal, there has lately been built a magnificent revetment wall of cut limestone, to the height of twenty-three feet above the summer level of the river. *This wall is now a great protection against the effects of the ice.* Broken by it, the ice piles on the street or terrace surmounting it and there stops; but before the wall was built, the sloping bank guided the moving mass up to the walls of gardens and houses in a very dangerous manner, and many accidents used to occur. It has been known to pile up against the side of a house, distant more than 200 feet from the margin of the river, and there break in at the windows of the second floor. I have seen it mount a terrace garden twenty feet above the bank, and crossing the garden enter one of the principal streets of the town. A few years before the erection of the revetment wall, a friend of mine, tempted by the commercial advantages of the position, ventured to build a large cut stone warehouse. The ground floor was not more than eight feet above the summer level of the river. At the taking of the ice, the usual rise of the water of course inundated the lower story, and the whole building becoming surrounded by a frozen sheet, a general expectation was entertained that it would

be prostrated by the first movement. But the proprietor had taken a very simple and effectual precaution to prevent this. Just before the rise of the waters, he securely laid against the sides of the building, at an angle of less than 45°, a number of stout oak logs a few feet asunder. When the movement came, the sheet of ice was broken, and pushed up the wooden inclined plane thus formed; at the top of which, meeting the wall of the building, it was reflected into a vertical position, and, falling back in this manner, such *an enormous rampart of ice was in a few minutes placed in front of the warehouse as completely shielded it from all possible danger*. In some years, the ice has piled up nearly as high as the roof of this building. Another gentleman, encouraged by the security which this warehouse apparently enjoyed, erected one of great strength and equal magnitude on the next water-lot, but he omitted to protect it in the same way. The result might have been anticipated. A movement of the ice occurring, the great sheet struck the walls at right angles and pushed over the building as if it had been a house of cards. *Both positions are now secured by the revetment wall.*"

Mr. Stephenson, upon being appointed the Company's Engineer, considered the subject of such importance, that he went to Canada, for the purpose of dealing with it, in 1853, and, after examining the facts, made a public declaration of his opinion that a bridge was practicable. On the 2nd May, 1854, Mr. Stephenson wrote to the Grand Trunk Railway Directors, in which he considered the whole question in three branches—

1st. As to the description of bridge best adapted for the situation.

2d. The selection of a proper site.

3d. The necessity for such a structure.

Upon the first point he did not hesitate to adopt a tubular bridge, as the best description fitted for a permanent, safe, and substantial structure in such a situation.

On the 2nd point he was not a little influenced by considerations affecting the flow of the river, and those almost

"irresistible forces" consequent upon the breaking up of the ice. Writing on this subject, he says:—

"The origin of these powers is simply the gravity of the mass occupying the surface of the water with a given declivity up to a point where the river is again clear of ice, which, in this case, is at the Lachine Falls. This is unquestionably the maximum amount of force that can come into play; but its effect is evidently greatly reduced—partly by the ice attaching itself to the shores, and, partly by its grounding upon the bed of the river. Such modifications of the forces are clearly beyond the reach of calculation, as no correct data can be obtained for their estimation; but if we proceed by omitting all consideration of those circumstances which tend to reduce the greatest force that can be exerted, a sufficiently safe result is arrived at.

"In thus treating the subject of the forces that may be occasionally applied to the piers of the proposed bridge, I am fully alive to the many other circumstances which may occasionally combine in such a manner, as, apparently, to produce severe and extraordinary pressure at points on the mass of ice or upon the shore, and, consequently, upon the individual piers of a bridge. Many inquiries were made respecting this particular view, but no facts were elicited indicative of forces existing at all approaching to that which I have regarded as the source and the maximum of the pressure that can at any time come into operation affecting the bridge.

"I do not think it necessary to go into detail respecting the precise form and construction of the piers, and shall merely state, that, in forming the design, care has been taken to bear in mind the expedients which have hitherto been used and found successful in protecting bridges exposed to the severe tests of a Canadian winter, and the breaking up of the ice of frozen rivers.

On the 3rd point, Mr. Stephenson proceeds to say:—

"I now come to the last point, viz., the necessity of this large and costly bridge.

"Before entering on the expenditure of £1,400,000 upon one work in any system of Railways, it is of course necessary to consider the bearing which it has upon the entire undertaking if

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quainted, only partially, with the tendencies of the trade which is growing up on all sides in Upper Canada, can fail to perceive, that, if vigorous steps be not taken to render the Railway communication with the Eastern coast through Lower Canada uninterrupted, the whole of the produce of Upper Canada will find its way to the coast through other channels, and the system of lines now comprised in your undertaking will be deprived of that traffic upon which you have very reasonably calculated.

"In short, I cannot conceive anything so fatal to the satistisfactory development of your Railway as the postponement of the bridge across the river at Montreal. The line cannot, in my opinion, fulfil its object of being the high road for Canadian produce, until this work is completed; and looking at the enormous extent of rich and prosperous country which your system intersects, and at the amount of capital which has been already, or is in the progress or prospect of being expended, there is in my mind no room for question as to the expediency, indeed, the absolute necessity of the completion of this bridge, upon which, I am persuaded, the successful issue of your great undertaking mainly depends."

Mr. Stephenson's design for the Victoria Bridge was severely criticized at the time by some very eminent English Engineers, particularly as being more expensive than the "Trellis Girder," or than the "Single Triangular Girder," recently called "Warren" from a patent obtained for it by a gentleman of that name; but Mr. Stephenson so clearly demonstrated his own views to the G. T. R. Directors, and so logically and forcibly discussed the whole question in a Report,—which is a perfect model of scientific reasoning from the pureness, simplicity, and clearness with which he places his arguments and opinions side by side with those of his critics,—that the Directors, unhesitatingly, decided upon adopting the bridge according to the design and estimate submitted to them.

In 1854 the work was commenced by the contractors, Messrs. Peto, Brassey, and Betts, under the sole superin-

tendence of Mr. James Hodges, the Engineer who acted on the part of the contractors; and, although the contractors were impeded in their progress, in consequence of the monetary crisis, which affected their own and the affairs of the country generally, the bridge was completed, and accepted from off the contractors' hands, on the 17th December 1859, being within one year of the time specified.

Before proceeding to give the reader a description of the Victoria Bridge, it may not be uninteresting to furnish a short account of its great rival the Britannia Bridge (so called from the rock on which its centre pier is raised), and which, although not near so long as the Victoria, still is pre-eminent among bridges for the lofty height of its towers, and for the length and dimensions of its tubes, which are the largest of any yet constructed upon the tubular principle.

The Conway Bridge, constructed over the Conway river in Wales, was the first tubular bridge ever constructed. It has only one span, 400 feet in length, and was the joint production of Robert Stephenson and William Fairbairn. This bridge was in itself an instance of "triumphant success in design and execution." It was followed, immediately after, by the Britannia Bridge over the Menai Straits, in the middle of which a rock rises from the bed of the sea, upon which a tower of masonry is erected 200 feet in height. At the clear distance of 460 feet, another tower is built on either side of it; and, at the distance of 230 feet from each of these towers, a continuous abutment of masonry, 176 feet in length, is erected, which constitute the two ends of the bridge. The Britannia tower, in the centre of the Straits, is 62×52.5 ft. at the base, and reduced, by batter, to 52×45.5 ft. at the height of 102 feet above the high-water line, at which level the tubes pass *through* it; and the elevation of the whole tower above high-water level is the lofty height of 200 feet, or nearly

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230 feet from the bottom of the foundation on the rock. The stones used, as in the Victoria Bridge, are of great size: some of them weigh from 10 to 14 tons. The cubical contents of this single tower, if solid, would exceed 575,000 cubic feet, but, as it is constructed with hollow spaces or chambers within it, the quantity of stone actually used in its construction is 293,150 cubic feet. The total weight of the masonry is 200,000 tons, and about 387 tons of cast-iron in beams and girders are built in it.

The abutments of this bridge terminate with projecting pedestals, on which four couchant lions, in the Egyptian style and of colossal dimensions, face the approaching visitors, and seem to guard the entrance to the iron wonder behind. Each of these lions measures 25 feet in length and 12 feet in height, weighing about 30 tons,—noble specimens of sculpture.

There were four spaces in the Britannia Bridge to be covered by the iron tubes, two of 460 feet and two of 230; and, as each tube serves for only one line of rails, 8 tubes were required. The four largest being over the deep water, they were constructed on the shore on timber platforms, and conveyed in flat-bottomed vessels, or pontoons, to the towers, and were raised to their required elevation, of 102 feet above the high-water level, by hydraulic presses; and, by this arrangement, all scaffolding across the Straits was avoided, and only one half of the channel interrupted at a time.

When the work was completed, the four separate tubes were united together, so that each tube is of the length of 1513 feet, or about $\frac{1}{4}$th of a mile; and to form this connection, short tubes were constructed within the towers to effect their ultimate union.

But the part in the design of this stupendous bridge, which evinced the boldness and confidence of its Engineer

in his own powers, was the raising of a weight of 1800 tons through an elevation of 102 feet, over a rapid tide rushing through the Straits, and utterly without scaffolding of any kind over the opening, between the towers, 460 feet in width.

The power applied for this Herculean purpose was those machines known as "Hydraulic" or "Hydrostatic Presses," a description of which it is unnecessary to give in these pages.

As the tube steadily and slowly ascended under the powerful pressure applied, the space underneath was carefully built up with brick work and cement. Mr. Stephenson had followed up the tube, inch by inch, as it ascended, with packings of wood 1 inch thick, until there was sufficient room to replace the packings with bricks; and if this wise precaution had not been adopted, an accident of a very serious nature would have occurred, owing to the bursting out of the bottom of the cylinder of the hydraulic press, weighing about 4½ tons, which, being entirely separated from the rest of the casting, fell, with terrific force, on the top of the tube below, a depth of from 70 to 80 feet. The tube would have fallen, in consequence, through a space of 3 feet 6 inches on the brickwork below, but was arrested by the packings of wood so wisely adopted. As it was, the total falling was only about *one inch*, and, although it only fell through that short space, it broke down iron beams sufficient to bear 500 tons weight.

Let us now draw a comparison between the dimensions of these rival bridges; by which it will be seen, that, however gigantic are the towers that uphold the ponderous tubes of the Britannia Bridge, as a work of magnitude and art it is far surpassed by the Victoria in the difficulties to be encountered in its erection, and in its general proportions.



	Brit. Bridge. Ft. in.	Vict. Bridge. Ft.
Length between the abutments.....	1,513	6,600
Total length including approaches.....	1,841.6	9,084
Number of piers.....	2	24
Greatest distance between piers.....	460	330
Height of Centre Tower (or pier) over high water.....	102	60
Total height of tower.....	200	60
Cubical contents of masonry in whole structure.....	1,300,000	3,000,000
Total weight of iron in single line of tubes.....	Tons. 4,825½	Tons. 8,000
Number of rivets in do do	1,000,000	2,000,000
Cost of Work.....		$6,300,000
Time occupied in completion..		5½ years

We will now proceed with a general description of the Victoria Bridge.

The Victoria Bridge is that known as the tubular or beam bridge, and consists of a series of iron tubes resting on 24 stone piers, with a distance between each pier of 242 feet, except the centre opening, which is 330 feet in length. Its total length between the abutments is 6,600 feet, or a mile and a quarter. The bridge is approached by two massive embankments, the one on the Montreal side being 1,200 feet, and that on the south shore 800 feet in length; which together, including the abutments, make the total length of the bridge 9,084 feet, or a mile and three quarters nearly.

Laying off the Work.

The first step taken, after the surveys were fully completed, and the line over which the bridge was to pass decided upon, was to lay off the line of the abutments and piers.

This work the Engineers were able to do, whilst the ice was on the river, with the most minute correctness. Then

the centre of the foundation of each pier was marked, which was thus performed. "Guides" were framed, so that long iron rods could be lifted and let fall on one spot, technically called by masons "jumped," until a hole was drilled into the rock, in the bed of the river, into which a bolt was driven and a float attached. By these means the precise centre of each pier was established to within a few inches.

Dams.

The first step to be taken before the foundation of the piers, or abutments, could be laid, was the formation of coffer-dams, which, for such a structure and in such a river as the St. Lawrence, required to be of no ordinary magnitude and cost.

Two kinds of dams are said to have been used, each possessing over the other certain advantages. Those called floating-dams were framed, and consisted of two parts. One part had three sides of a rectangular form, the sides being longer than the ends, but the upper end was formed of two pieces meeting in an angle up stream, in order to turn off the current. They were carefully and strongly built, and caulked; and were then towed into position by a powerful steamboat, and their precise places determined by a transit from the shore. On a given signal the sluice-gate was opened, and the dam sunk into its required place. The area within the dam was of course still water, and within its sides was constructed another dam; on the completion of which, the water was pumped out.

The other form of dam was of the ordinary cribbing of the country, and, owing to the rapidity of the stream, unusual care had to be observed in its construction.

A dam of this form, consisted of a double row of cribbing, each 14 feet wide, and with seven to eight feet of puddle; and between them, and the part turned up stream,

was a regularly built ice-breaker to withstand the ice of the winters if necessary. The comparison between the respective merits of these two classes of dams may thus be made. The floating dam could be used several times, and was found to answer best in deep water; but its great disadvantage was, that the masonry of the pier had to be completed within the working season, as it could not be made sufficiently strong to resist the pressure of the ice in winter, hence, it had to be removed; also, when the period arrived to construct the tube, the side of the pier was naked, and there was no point whence to start the scaffolding to support the tube-truss.

With the coffer-dam this foundation for the scaffolding existed, and, hence, it was only necessary to frame one centre scaffold; whereas, with the floating-dams, three such constructions were necessary, viz., the centre, the frame, and the scaffold foundation at the side of each pier. Nor was this consideration an unimportant one, for such foundation had to be obtained by sinking scows and driving piles around them to keep them in position.

From either dam the framing was carried up above the height of the pier, and on the capping piece, or sill, was run a railway to admit of the passage of a travelling machine, which, mounted with a crab, admitted a contrary passage on itself. Hence stones of 17 tons were moved into position with the greatest facility. On the platform of the dam were erected sheds to cover the steam-engine, the blacksmiths' and carpenters' shops and storeroom.

The foundation of the piers seldom exceeded 22×90 ft., whereas the area required for the dams was 120×210 ft. to allow a large margin in case of its not sinking in the exact spot.

Nothing could be better than the pumps used by Mr. Chaffey, the contractor for masonry on the south side of the

river. They were worked centrifugally, and threw 800 gallons a minute. It was calculated that his pumps lowered the area of water in the dam at the rate of two feet per hour, and emptied a dam in eight or ten hours.

When the dams were perfected and emptied of water, the staging constructed, the travelling machine in operation, stone delivered and cut ready to be laid on its bed, the next process was that of cleaning out the bed of the river for the foundation.

Bed of the River.

It was the general impression that the bed of the river was rock, of that kind termed "trap," but in the progress of the work it was found that it was formed of large boulders heaped together in masses, the interstices being filled up with gravel, sand, and mud, in many instances forming a hard concrete mass, and in others the reverse, beds of quicksand and mud being as frequent as any other. Three thousand tons of such material had to be cleared out of the foundation of No. 5 pier. One of the boulders taken out weighed 30 tons, and masses of three and four tons were strewed thickly over the surface.

The depth, therefore, to be excavated, before reaching rock, greatly increased the cost to the contractors of the masonry in the piers.

We should observe, that in the southern half of the bridge (for it was commenced at both ends at once) the scaffolding was not used, but a compound derrick, the invention of Mr. Chaffey, worked by a high-pressure engine, supplied its place. Much ingenuity was shown in obtaining this motion, as the stone could be placed by it in any position, for the derrick had a motion which admitted of precisely placing the stone in position. It was capable of handling stones eleven tons in weight.

The Approaches and Abutments.

The bridge is approached from the north shore by an embankment 1,200 feet, and another from the south shore 800 feet in length, and the waters, thus embayed, now find their way through the piers of the bridge, by which the velocity of the current has been much increased.

The abutments are each, at the base, 278 feet long, and are built hollow, having eight openings or cells 48 feet in length and 24 feet in width, separated by cross-walls 5 feet in thickness. The flank-wall on the down-stream side rises nearly perpendicular, and is seven feet in thickness; that on the up-stream has a slope from its foundation upwards, the thickness of the walls is 12 feet, and they present a smooth surface to facilitate the operation of the ice, on which account its form had been thus determined. To ensure greater resistance to the pressure of the ice, the cells are filled up with earth, stone, and gravel, so that one solid mass was thus obtained.

The embankments are solid, composed of stone 36 feet above the summer water level, and of the width of 30 feet on the upper surface, formed with a slope of one to one on the down side of the stream, and a hollow shelving slope of about 2½ to one on the upper side. The slopes are faced with stones set on edge at an average angle of 45°.

Piers.

The piers are solid, and constructed, as well as the abutments, of the finest description of ashlar masonry, laid in horizontal courses measuring from 7 to 12 feet on the bed, and from 3 ft. 10 in. to 2 ft. 6 in. thick, above the water level, and thence varying into a course of 18 in. under the plates. The stones were cut with the greatest exactness, seldom requiring to be re-dressed after being laid.

They weigh from 7 to 17 tons; the average weight of each stone is 10½ tons. All the beds and vertical joints are square, dressed in the most efficient and workmanlike manner; the external face rough, and without any pick or tool marks, but with the natural quarry face preserved.

The string-courses and copings are fair-picked, dressed throughout, and neatly pointed and weathered, and a tool-draft, eight inches wide, on each quoin. Each course of the ice-breaker is secured with fox-wedged bolts of 1½ inch iron, which pass through into the 2nd and 3rd courses under it; and the horizontal joints are cramped together with iron cramps 12×5 inches, through which the bolts pass.

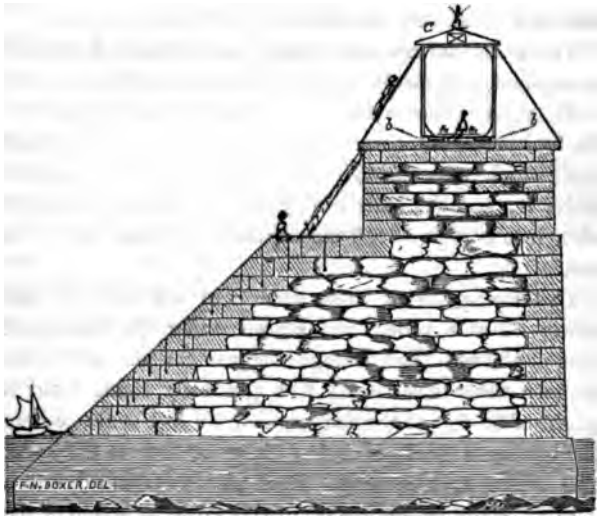
The description of stone used is a limestone of the Lower Silurian order, and known under the Geological term of Chazy. The average height of the piers above the summer water level is 48 feet, gradually rising from a height of 36 feet at the abutments to 60 feet at the centre pier, giving a grade of 1 in 132, or 40 feet to the mile. The centre span is level. Each pier is furnished with a solid cut-water, or ice-breaker, which forms a portion of the pier itself. They are of a wedge form, and slope from their foundations upwards, terminating in an angle 30 feet above the summer level of the river. Their use, and the protection they afford, have already been alluded to in Mr. Stephenson's Report. The dimensions of a pier at the junction, with the cut-water, are 16 ⋈ 48 ft., but the whole transverse side of a pier at the foundation, including the cut-water, which extends up the stream, is 16 ⋈ 90 feet.

The foundations, of course, vary; some are as low down as 20 feet below the water.

The whole of the ashlar is laid in hydraulic cement, in the proportion of 1 part sand to 1 part cement. The

backing, from the level of the surface water upwards, is in common mortar.

The following is a section of a pier and tube:—



c. The roof. *b*. The rollers.

Although it is difficult to particularize one individual more than another, when all did their work so well, yet the name of Mr. Chaffey, the sole contractor for the mason's work for the southern half of the bridge, deserves especial mention. Few people can realize how much of labour and mental anxiety is saved to an engineer who has to deal with an honourable, energetic, and talented contractor, and all this was combined in Mr. Chaffey.

Our space will not allow us to enter into an account of the ingenious expedients he adopted for the saving of labour; and we regret, for the same reason, that we cannot enter into a description of his Derrick and Steam Traveller, a

model of which we hope some day to see in the Exhibition Building, in this city, of the L. C. Board of Arts and Manufactures. For beautiful mechanical contrivance, simplicity, and capability of power, his compound Derrick is foremost among lifting-machines.

The best tribute, as a man, we can pay to Mr. Chaffey, is to say, that of him all men speak well.

Tubes.

The plates of the tubes are of various dimensions and thicknesses. Those forming the sides are reduced in thickness from the ends towards the middle, varying from $\frac{5}{16}$ to $\frac{3}{8}$ of an inch. The joints are strengthened with Tee irons. The kelsons are placed transversely across the bottom of the inside of the tubes, and are 10 inches in depth. They are spaced 7 feet apart and are secured to the Tee bars by gussets, and support the pine longitudinals, or stringers, which carry the rails. The longitudinals are about 12×12 inches in section, and are kept in place by wrought iron flanges which are bolted to the kelsons. This arrangement allows the tubes to contract and expand without disturbing the pine longitudinals and the rails which rest upon them. They move freely between the flanges which form their lateral support.

The plates are all butt-jointed, having a covering plate over the joints on the outside, which is firmly rivetted through to the Tee iron on the inside of the tube; and covering plates, both inside and out, are placed over all the horizontal joints.

The centre tube, being so much longer than the others, has an additional thickness in the plates, and longitudinal kelsons are rivetted to the top in place of the Tee bars used in the small tubes. The Tee bars and gussets are are also considerably larger.

This tube is connected, at one end, to one of the large

piers; the other end is left free, resting upon the iron rollers.

The iron brackets protecting the exposed surface of the top of the two large piers are partly glazed, and at the sides of the brackets are iron blinds, through which a splendid view of the massive masonry of the piers and ice-breakers can be obtained; but on account of the great risk that strangers, particularly women, would be exposed to in the narrow tube during the passing of a train, the authorities very properly refuse admission to the public.

Between the bottom of the tube and the stone work of the pier, is introduced creosoted tamarac covered with asphaltic felt. The object of this is to give elasticity between the iron work and the stone.

On one side of the interior of the bridge is a planked footpath 3 feet in width, resting on the kelsons. It is only intended for the use of the *employés* in charge of the bridge. There is no footway for passengers on the outside of the bridge.

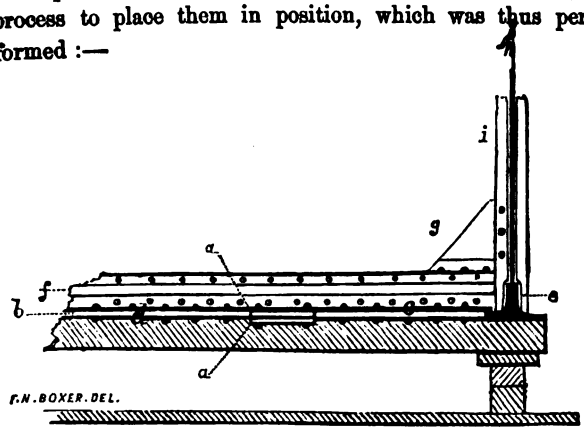
The greatest difference caused by expansion in the length of a tube of 260 feet, registered between the greatest extremes of temperature, is under three inches. At one end of the bridge is placed an indicator for registering the daily contraction and expansion of a tube. The telegraphwires pass underneath the tubes.

The deflection of a single tube, under the severest test that could be brought to bear upon it, was $\frac{7}{8}$ of an inch; that of the largest tube was $1\frac{7}{8}$ inches. Upon the load being removed, the tubes returned immediately to their original level.

The following was the method adopted for putting the tubes together:

After the staging or scaffolding was completed, upon

which a tube was to be built, blockings, supporting cross ties, were placed at intervals of about four feet for the whole length of a tube, and were raised sufficiently above the floor of the scaffolding to admit of the riveters working between this floor and the bottom of the tube; at the same time, the requisite camber of the tube was carefully preserved, to allow of its settling down to a level when the scaffolding was removed. The centre line of the tube was then carefully struck on the cross ties which were placed to support the bottom plates. The plating was then commenced, either at the "bearing" or "roller" end, as the case might be. As the plates were all ready marked, punched, and numbered, each plate having its own particular place assigned for it in the tube, it was but a simple process to place them in position, which was thus performed :—



1st. The "bottom strips," *a* on plan, which join the plates making up the width of the tube, were laid down; then the "bottom plates," *d*; next the "cover plates," *c*; the packings, *b*; the angle irons, *e*; the cross kelsons, *f*; and the *tee* irons, *i*. As the plating proceeded, the riveters followed up their work here and there with rivets, to keep the pieces toge-

ther; and when the bottom was completed, the side plates, which were riveted into large sheets on shore, were commenced at the *centre* of the tube and proceeded with towards the ends. As fast as these large sheets, *h*, were placed together, the bottom "gussetts," *g*, which join the sides with the kelsons, were bolted in, and the top kelsons raised to position.

The laying of the top plates of the tube was but a repetition of the mode adopted for the bottom ones. Particular care, however, had to be taken in watching the camber of the tube as its weight increased, and wedges were provided under the blocking to raise it up, if required.

We mentioned that the tubes of the Britannia Bridge, after being placed in position, were connected with short tubes built in the towers so as to form one continuous length from shore to shore. In the Victoria Bridge a different arrangement was necessary on account of its grade, and the greater expansion and contraction of iron during the sudden extremes of temperature in this variable climate. The tubes of the Victoria Bridge are only connected in pairs. They cover two openings of 516 feet in length, including bearings, and contract and expand on iron rollers. They are 16×19 ft. at the ends of the Bridge, but they increase in depth towards its centre, at which point they are 16×22ft.

The weight of two united tubes, with rails, &c., is about 514 tons, or 257 tons for each opening.

The construction of this character of work is now so well known that much allusion to it is not necessary. Moreover, it is simple in the extreme, being formed of boiler plate rivetted together with angle irons and lateral and transverse braces, as shewn in foregoing illustration. The skill lies in reducing this boiler iron to such dimensions that there is no unnecessary material to add to the weight and to the expense, and yet obtaining a sufficiency of strength.

Accordingly, where the sides of the tube require strength, is at the abutment. Thus it will be seen that for the top and bottom of the tube the greater strength is at the centre, whereas the sides have most material where the span starts.

Thus, taking our data in all cases from the centre, the following shows the component parts of the tube :—

TOP PLATES.

From Centre.	L'ngth of Division.	Sectional Area. Plates.	Strips, Tee and Angle Irons.	Total Area.	Thickness of Plate.
	′ ″				
1	11.00	125	92 1/16	217 1/16	5/8″
2	11.00	125	86 7/16	211 7/16	9/16″
3	11.00	114 3/4	86 7/16	200 11/16	9/16
4	11.00	107 1/16	84 11/16	191 12/16	1/2
5	11.00	87 1/2	84 11/16	172 3/16	7/16
6	11.00	75	77 5/16	152 5/16	5/16
7	11.00	56 11/16	77 5/16	134	5/16
8	11.00	53 1/4	55 1/4	108 1/2	1/4
9	11.00	50	55 1/4	105 1/4	"
10	11.00	50	48	98	"
11	11.00	1	"	"	"
Bearing.	8.00				
	129.00				

BOTTOM PLATES.

1	19.6	137.50	63.75	201.25	5/8 — 5/16 Double.
2	14.0	137.50	57.75	195.25	" — "
3	14.9	125.00	57.75	182.75	" — "
4	14.0	112.50	54.25	166.75	5/16 — 4/16
5	14.0	87.50	57.50	145	4/16 — 3/16
6	14.0	85.00	33.00	118	5/16
7	14.0	50.00	42.00	92	4/16
8	17·6	50.00	42.00	92	4/16
Bearing.	8	50.00	22.00	92	4/16
	129.0				

SIDE PLATES.

Beginning at the centre, and strengthened by lateral irons inside and out, placed at distances of 3,′ 6″,—

The first space, 35 feet from centre is formed of ¼ inch plate.
The second space of 45½ feet " " $\frac{5}{16}$ " "
The third " 35 " " " $\frac{6}{16}$ " "
The remaining space " " " $\frac{8}{16}$ " "

The immediate part of the tube resting on the pier is likewise strengthened by increased lateral bracing.

At the line of neutral axis a few small circular holes are perforated in the side of the tube to throw light into the interior.

Over the top of the bridge is constructed a light roof of wood, on the ridge of which is a foot-walk 26 inches wide; and a track is also provided for the painting travellers. The roof is covered with tin; and the frame and tin work are so arranged as not to be injured by the expansion or the contraction of the tubes.

The sides of that portion of the top of the piers on which the tubes do not rest, are covered with iron brackets, which protect the masonry of the pier, and also prevent snow from blowing in through the space left for the expansion of the tubes.

The tubes themselves were constructed in position, and the difficult and expensive process of floating them from the shore and lifting them by hydraulic pressure was thus dispensed with. Where the coffer-dams were in use, the framing was carried up from them; and in the centre, a scow was anchored and piles driven in around it, on which the scaffolding rested. It was here that the difference between the two systems of dams was apparent. In the one three scows secured with piles was necessary; in the other, but one. On these supports a truss was formed on which the tube was put together.

The following wood-cut shows the description of truss used for this purpose:



The Expansion Rollers are seven in number in each set, of 6 in. diameter, in a cast-iron frame, rolling on planed bed-plates. The rollers themselves being turned and the beds plated, they run as smoothly as on glass.

Riveting.

The rivets are an inch in diameter, and are arranged in rows. They were heated in portable furnaces, which were moved from place to place as the work proceeded. From these forges the rivets were taken up with tongs by one of the boys attending and thrown to the rivetters on the stage above; and it was extraordinary to remark with what dexterity and precision these lads would throw the rivets and make them curve over the stage and fall to right or to left on any spot they desired. The rivets were then placed in the

holes punched for them, and the ends firmly clenched with heavy hammers before cooling.

The rivet head, thus formed, is in a rough shape, and is finished by placing a steel cup-shaped tool upon it, which, being struck with a heavy hammer, the head of the rivet becomes formed perfectly smooth and convex in the steel mould. The contraction of the length of the rivet, in cooling, draws the plates close together with considerable force.

It required no small amount of nerve for the inquisitive visitor to pass through the fiery ordeal. As he gradually approached through the dark tube, the hollow sounds of the heavy hammer on the iron plates reverberated from side to side with a thousand echoes on the ear; but when he arrived at the actual scene of work, it would be difficult to describe the feelings of the looker on. The strokes of the hammers no longer had a deep sonorous sound, but fell with a hard and clanging ring upon the ear that threatened to rupture its tympanum—the darkness of the place—the dim glare of the smoky furnaces—the fiery darts shooting around, and the dark and shadowy objects flitting here and there, like spirits of another world, altogether had such a bewildering effect upon the senses, that the classical reader, for a moment, might fancy himself in the reigons of old Vulcan, surrounded by his Cyclops forging the thunderbolts of Jupiter.

In the fall of 1859, the last tube of this wondrous work was completed; and on the 17th December of the same year, Mr. J. Bruce and Mr. P. Stockman, Civil Engineers, who were sent out from England, at the desire of Mr. Stephenson before his death, to test the strength of the tubes and to examine the work, made their formal report; part of which will be found in the appendix.

The reader, as he has stood on the banks of the St.

ence, and admired the noble Bridge which crosses the immense volume of water flowing onwards to the , and wondered at the talent and genius of the men onceived, designed, and carried out so stupendous a , when so many difficulties had to be encountered, robably think for what great purpose has so immense a of money been expended in its construction. Was it mbition, pride, or folly of the Colony to eclipse the world in this Titanic structure? or did it ate from the wisdom of its people, who considered nstruction absolutely necessary for the completion of great national and commercial policy?

ere are some nations, who, though blessed with a f the greatest fertility, with a climate of the most gelescription, and with resources, which, if developed, l render them the richest, happiest, and most powerf people, yet, from their natural supineness and conional indolence, have no desire to cultivate and im- the rich gifts so bounteously bestowed upon them by e, nor the energy to become great and powerful.

ow different is the character of the Anglo-Saxon and ch races! No matter in what part of the world they fix abode, or what difficulties they have to encounter, progress is ever marked by rapid civilization, prosy, and wealth. Success seems to follow in their footsteps. l the British Colonies which now or once belonged e English realm, may be seen the striking contrast en the Anglo-Saxon and other nations of the earth; he same remark may be now applied to the people of ce.

om the date that Jacques Cartier first landed on the s of Canada in 1554, up to 1760, there was a period most incessant warfare between the brave French rs and the aborigines of the country; the latter fre-

quently assisted by British troops. During the period of these early struggles, little progress could be made either in civilization or agricultural improvements: it was as much as the hardy French adventurers could accomplish to hold their ground against a fierce, savage, and implacable foe. But a century and a half by-gone, in this same city, now so flourishing and adorned with costly edifices, and whose streets, in a few short weeks, will be thronged with thousands of strangers assembled from different parts of this Continent to witness the celebration and the inauguration of the greatest engineering work in the world, by the heir of Britain's Throne; yes, reader, in this city—now so fair and happy, but then consisting of but a few straggling houses surrounded by a rude fortification—did 1200 warriors of the Iroquois tribe make a sudden descent, and 1000 of the brave French settlers fell under the tomahawk and the scalping-knife of the ruthless savage. Mother and infant met with no mercy from the fiend-like foe, who savagely killed, burnt, destroyed, and laid waste all around, carrying off twenty-six of their captives to meet a still more horrible death by torture at the stake.

Nor did the horrors of war cease with the ceding of this Colony to the British Crown. In 1775 commenced the struggle of the American Colonies for their freedom; and from that date until 1814, the blood of many a brave Canadian stained the soil in loyally fighting for the Crown of England.

But though peace had at last found a resting-place on the soil of Canada, yet years passed away before any reaction took place after so long and desolating a war; and even thirty years ago, Montreal was thus characterized by an American writer:—

"The approach to Montreal conveyed no prepossessing idea of the enterprise of its municipality. Ships, barges, and steamboats

lay on the margin of the river, at the foot of the hill. No line of wharves built of substantial limestone, of which there is abundance in the neighbourhood, afforded security to vessels and owners. The commercial haven looked as ragged and muddy as the shores of New Nederland when the Guedevrow first made her appearance off the Battery."

Nor was the progress of other Canadian cities at all remarkable; as a well-known writer in this city has thus described the state of Canada a few years back:—

"Then no great chain of railway linked town to town and city to city, almost annihilating distance. Then the journey to Toronto was a toilsome matter of weeks; and that to Brockville, short even as is the distance, occupied, with heavy cumbrous *batteaux*, three weeks. Now how changed! The wand of some fairy king has surely been here. But no! Industry, intelligence, labour, capital, all combined, and working for the advancement of this rising Colony, have produced the marvellous changes which meet us on every hand."

To the effect of the onward movement of immigration of a hardy, enterprising, and persevering race, the infusion of new blood, and the changes brought about in the administration of the affairs of the Province, may mainly be attributed the unprecedented prosperity of Canada in so short a period, far exceeding that ever recorded in the annals of the history of any country. Montreal in 1843 contained about 45,000 inhabitants; it now nearly doubles that number. In 1842 Toronto contained but 13,000 people; its population now is close upon 50,000. Kingston in ten years doubled its inhabitants, and London in one year added 30 per cent to its number, whilst a corresponding increase took place in almost every town in Upper Canada. Ottawa, soon to be the future capital of Canada, contained in 1830 but 150 houses; it now has a population of about 14,000. The farm on which the city now stands was purchased but a few years ago for £90; and it is even

stated that the proprietor, who is still living and said to be immensely wealthy, afterwards most bitterly regretted his bargain, little dreaming that in so short a space of time a city would be built upon its rocky surface.

The great agricultural resources of the country were rapidly becoming developed; and although, through the foresight of Government, spacious canals and other expensive public Provincial works were constructed for the advancement of her prosperity, still the rigour of the climate, which, during six months in the year, closed up her ports, rendered it impossible for her to cope with her powerful, ever-active, and enterprising neighbours, unless some means of transit were afforded, direct to the open sea, during the period that the navigation of the St. Lawrence was impeded.

We need not enter into the details of the establishment of the great Canadian system of railroads. The remedy to the disadvantages under which this Colony labored was to be found only in their construction. The credit of the Province was pledged, English capital was obtained, and Canada is no longer isolated during the long period when nature throws an icy warp over her deep broad rivers and inland seas. The connecting link to this great chain of railway was, however, still wanting; but that now is accomplished, for the Victoria Bridge links Canada's prosperity with that of the wide world, and all the benefits that will accrue to the Province from her great Bridge and Railways, however dear she may have paid for them, is yet to come: it is but the beginning of the end. The traffic that has passed over the line has considerably increased since the bridge has been finished; and some idea may be formed of its advantages when we mention, that, in five nights after trains could run through the bridge, 292 cars passed through, containing 11723 barrels flour, 1552 barrels

pork, 140 bales of cotton, 644 tons general goods, 170 tons iron, and 39,000 feet of lumber.

Facilities for the transmission and the delivery of freight are now afforded by the Grand Trunk Railway unequalled by any other line; it having but one trans-shipment between Cincinnati or Chicago and the Eastern States, and none between the west of Canada and the same places. In one direction, easterly, its line extends from Portland, in Maine, to Quebec and to Riviere du Loup, in Lower Canada; and will doubtless soon be connected with Halifax, in Nova Scotia: whilst in Upper Canada, it extends, in a westerly direction, to London, Detroit, and Michigan; passing through Montreal, Brockville, Kingston, Belleville, Cobourg, Port Hope, Toronto, Guelph, and Sarnia, and connecting with the other railways in Canada. The day too may not be far distant when this line of railway will reach the shores of the Pacific Ocean. What will be the beneficial result to Canada, time alone will tell; but, judging from the past, if her prosperity goes on increasing with the facilities offered for opening up the country, for extending its commerce, and developing its resources, it will be great indeed.

In concluding these remarks, it may not be uninteresting to the general reader to hear of the incidental occurrences which took place during the construction of the Victoria Bridge, copied partly from the *Montreal Gazette*. Of course, the laying of the first stone was the primary event in connection with its construction. This took place on the 22 July, 1854.

The coffer-dam for No. 1. pier having been floated into its place, sunk, water pumped out, and all made right and tight, the principal officers of the Company, Sir Cusack P. Roney, Managing Director; Benjamin Holmes, Esq., Vice President; Hon. Peter McGill, Alex. McK. Ross, Chief

Engineer; Mr. Grant, Assistant Secretary; S. P. Bidder, Esq., Manager; the representatives of the City Press, and a large party of ladies and gentlemen were present at the ceremony, at the invitation of Mr. Hodges, the Agent of the Contractors.

The party having descended to the bottom of the coffer-dam, the stone was laid with all the ceremony used on similar great occasions. After the ceremony, the guests partook of a sumptuous luncheon served up in the bottom of the dam, which was followed up by a dance, and the "gruff old St. Lawrence never had its bed kicked about by a happier set of people." Just as the festivities concluded, a heavy thunder-storm commenced; as if old Vulcan was testifying his anger at the commencement of a work that was to eclipse all that had ever been wrought by his heathen deityship, with his black Cyclopean crew, in the forges of Mount Ætna.

On the 13th of March, 1856, a great celebration took place in Montreal to commemorate the completion of the Grand Trunk Railway to Toronto. It was indeed a gala time.

At an early hour the streets presented a most animated appearance. Bright coloured flags gracefully floated from the windows and the house-tops, or were suspended across the streets. The streets were crowded with strangers. Every window was crowded with the fair sex, who looked down with delight on the grand procession slowly moving along in the streets below, the effect of which was very striking.

In the evening, a banquet and ball was given at Point St. Charles, in one of the immense rooms connected with the Engine Station. The room was beautifully and tastefully decorated. The rafters were adorned with Cupids holding vases of flowers pendant from the roof,and surmount-

ed by the flags of Britain, France, and the United States. Between each pair of pilasters, along the sides, were suspended the names of cities, alternated with the names of celebrated men.

On each alternate pilaster the monogram of the Grand Trunk Railway was intertwined; on the others were shields displaying the flags of Sardinia and Turkey; and stretched along this was the motto, "Success to Mercantile Enterprise, Railways, Telegraphs, and Ocean Steam-Ships." Below these shields was a view of the Grand Trunk Railway Bridge over the River Credit. On one side of this, was placed the motto "Better do it than wish it to be done;" and on the other side, "Magnanimity is the bond of friendship." At the other end of the room was displayed a railway trophy surrounded by green boughs, having in the centre a view of the Victoria Bridge supported by railway and mechanical implements, and figures emblematic of agriculture and mechanics. On the right were observed the mottoes "God helps them who help themselves," and "Past labour is present delight." In the centre of the room was placed the *dias* for distinguished people and speakers; and from the roof, over the *dias*, was suspended a beautifully emblazoned shield, bearing the arms of the Governor General, draped with the flags of Britain and the United States, with the mottoes "Few things are impossible to skill," "Industry is never unfruitful," "Business is the salt of life," "Men climb to honor by prudence and industry." Opposite, was the orchestra, prettily painted in panels surmounted by pendant bouquets. Over it were displayed the mottoes "That is gold which is worth gold," "Deeds are fruits," "Words are but leaves." The whole sides of the room were hung with garlands of green boughs twisted, interlaced, and looped up with pretty fastenings upon the buttresses.

The *coup d'œil* on entering was really magnificent. The whole area of 34,000 square feet, unbroken by any obstacle to sight, sparkled and glittered with decoration; while the otherwise sombre hue of the heavy timbers of the roof, was broken by the sky-light running along the ridge, for several feet on either side, giving the whole a fine and equally diffused light.

When the guests were seated, the effect was grand; giving one a distinct conception of the term often, and sometimes so magniloquently used as a "sea of faces."

It were needless to mention here the names of all the principal parties who sat down to the Banquet. Amongst the most prominent was His Excellency the Governor General; the Anglican Lord Bishop of Montreal, besides all the notables of the Province, and from every part of the United States Various toasts were given and responded to; and the observations that fell from the lips of some of the distinguished men on this occasion deserve to be mentioned.

His Excellency the Governor General, Sir Edmund Head, said:—

"He felt assured that the celebration was one which the future historian would look back at with satisfaction: it would make a bright page in the history of Canada. It was in 1830 that Lord Durham made his Report on Canada, and how did he describe it? He stated, that, except in a few spots, the country was *wild* and *desolate*. But now what was the condition of Canada? The country produced not only enough to supply our own needs, but exported to the United States, and to Europe; and all this progress had been made in 17 *years*. Since Lord Durham wrote his Report, instead of the 15 miles of railway that then existed, there were nearly 1500 miles open. The whole country is now opened up, and the markets of Europe rendered accessible to the people. The former tedious journey from Quebec to Montreal was now performed in five or six hours; and the traveller might go from one end of the Province to the other in 24

iours. The Victoria Bridge would render Montreal famous for ›ne of the most wonderful works in the world. His Excellency .hen alluded to the Victoria Bridge, connecting the splendid ınd rich valley of the Ottawa with the South."

Senator Wilson, of Massachusetts, in returning thanks 'or the health of the President of the United States, said :—

"We witness the prosperity of the British Colonies in North America, not only without jealousy, but we witness it with ›ride and admiration. Your prosperity is our prosperity. We ıre bound by a thousand associations of blood and kindred. We are connected together by those mighty improvements which we are met here to day to commemorate. We are beginning to understand each other, to value each other, to be proud of each other's prosperity and success; and God grant that the ions of British North America and the sons of the North American Republic may never meet again on the banks of the St. Lawrence, on river or lake, on land or in any other way, than that in which we are all met to-day, to grasp each other's hands in friendship, and to aid and to encourage each other in the development of the resources of the North American Continent."

Colonel Taché also spoke to some length. He remarked :

"I will admit that a few years back I was one of the unbelievers. I never thought that this great work we are now called ıpon to celebrate to-day, would be seen by the present generation ; but that it would be the lot of future generations to see it. thought so, because there were so many obstacles, so many lifficulties, in the way."

Four thousand guests sat down to this great banquet, who were invited to it from all parts, from the Mississippi ›n the West to Newfoundland on the East.

On the 15th August, 1859, was laid the foundation-stone of the last pier of the Victoria Bridge. Some 300 adies and gentlemen were present at the ceremony, besides :he members of the City Council, Board of Trade, and eading citizens of Montreal. The stone was laid by Mrs. Hodges, who performed the duty with feminine graceful-



ness. It was slowly lowered down into, almost what may be said to be, its eternal bed, amidst the cheers of all present. The foundation-stone of this pier, which is one of the two large centre piers, was laid upwards of thirty feet below the level of the river, on a bed of solid rock. Mr. Ross, chief engineer, stated that "upwards of 3,000,000 cubic feet of limestone was used in the work; and when you consider that the period of our labour is restricted, in each season, to an average of 100 days, reckoning each day at 10 working hours, or 1,000 hours in a year, it shews that we have laid 500,000 feet each year, equal to 5,000 feet per day, or, coming down lower still, 500 feet per hour. You will thus find that we have performed an amount of work unequalled by any previous work of art in the world."

To witness the ceremony was indeed an event in a man's life, and bits of the rock were carried off by many who witnessed the laying of the foundation-stone of the last pier of the great Victoria Bridge.

One more event must be mentioned, illustrative of kind and sympathetic hearts in the bosoms of the mechanics and workmen under the employ of Mr. Hodges. On the east side of the embankment of the Victoria Bridge, at Point St. Charles, is a spot of ground which was set aside by the Provincial Government for the interment of immigrants. In this burial-ground are deposited the remains of upwards of 6000 human beings, the victims of that pestilential fever which, in 1847-48, carried off whole families of immigrants who had fled from the famine and the pestilence that was raging in their native land, only to die upon their arrival on a foreign shore, without a friend, perhaps, to close the eyes, soothe the sufferings of the dying, or to shed a tear over the unmarked grave of the poor immigrant.

Actuated with the noble feeling that all men are brethren, the *employés* of Mr. Hodges, to commemorate their sad

and unhappy fate, and to point out to the passing stranger their last resting-place, placed in the burial-ground a large boulder taken out of the foundation of one of the piers, weighing over 17 tons, of which the following, with its appropriate inscription, is an illustration:



Reader, we have endeavoured to give a sketch of the history of the great Victoria Bridge, but we feel how inadequately has the task been accomplished. The man of science will feel disappointed that these pages are so barren of scientific matter; but we have reason to hope that a large work of great merit, will, ere long, be published in England by one who built the Bridge.

There is, however, a moral in its history, a practical illustration, that when great ideas are conceived by men of



sense, however impraticable they may appear to the multitude at first, learn not to despise them. The greatest discoverers that the world has ever known, have been laughed at as fools, or treated as madmen; and the Victoria Bridge would not at this day have been built across the great river St. Lawrence, had those who conceived the idea been weak minded enough to succumb to public opinion.

APPENDIX.

REPORT OF ROBERT STEPHENSON.

To the Chairman and Directors of the Grand Trunk Railway Company of Canada.

Gentlemen,—Having learnt that some doubts have been expressed respecting the fitness of the designs for the Victoria Bridge across the St. Lawrence at Montreal,—that it is more costly than necessary, and that other systems of structure less expensive, yet equally efficient, might with propriety be adopted,—I feel called upon to lay before you in some detail the considerations which influenced me in recommending the adoption which is now being carried out. In doing so, I beg to assure you that the subject was approached in the outset, both by Mr. Alexander Ross, your Engineer in Canada, and myself, with a thorough consciousness of the enormous expense which must inevitably be involved, whatever description of structure might be adopted; also of the large proportion which this cost must bear to the entire outlay of the undertaking of the Grand Trunk Railway of Canada. We were, therefore, fully alive to the imperative necessity of studying the utmost economy in every part of the work, consistent with our notions of efficiency and permanency.

It will be my endeavour, in the following remarks, to satisfy you and those interested in the undertaking, that these object, have been steadfastly kept in view.

It would evidently be unreasonable to expect, that, amongst professional men, an absolute identity of opinion should exist, either in reference to the general design, or in many of the details, of a work intended to meet such unusually formidable



natural difficulties, as are to be contended with in the construction of a bridge across the St. Lawrence.

You will remember that at the time I first entered upon the consideration of the subject, these difficulties were deemed by many well acquainted with the locality and publicly stated by them, to be, if not insurmountable, at all events of so serious a character as to render the undertaking a very precarious one.

The information I received respecting these obstacles, when my attention was first drawn to this project, was so striking, that I reserved forming an opinion until I had visited the spot, had well considered all the detailed information which Mr. Alexander Ross had collected, during several months' previous residence in the country; and had heard the opinion of many intelligent residents regarding the forces exhibited by the movements of the huge masses of ice during the opening of the river in spring.

The facts gathered from these sources fully convinced me, that, although the undertaking was practicable, the forces brought into action by the floating ice, as described, were of a formidable nature, and could only be effectively counteracted by a structure of a most solid and massive kind.

All the information which has been collected since I made my first report, has only tended to confirm the impressions by which I was then guided.

For the sake of clearness and simplicity, the consideration of the design may be divided into four parts:—first, the approaches; secondly, the foundations; thirdly, the upper masonry; and, fourthly, the superstructure, or roadway.

The approaches,—extending in length to 700 feet on the south or St. Lambert side, and 1300 feet on the Point St. Charles side,—consist of solid embankments, formed of large masses of stone, heaped up and faced on the sloping sides with rubble masonry. The up-stream side of these embankments is formed into a hollow shelving slope, the upper portion of which is a circular curve of 60 feet radius, and the lower portion, or foot of the slope, has a straight incline of three to one, while the down-stream side, which is not exposed to the direct action of the floating ice, has a slope of one to one. These embankments are being constructed in a very solid and durable manner, and from their extending along that portion of the river only, where

the depth at summer level is not more than two feet six inches; the navigation is not interrupted, and a great protection is, by their means, afforded to the city from the effect of the "shoves" of ice which are known to be so detrimental to its frontage.

For further details on this subject, I beg to refer you to the Report made by Mr. Ross and myself on the 6th of June, 1853, to the Honourable the Board of Railway Commissioners, Quebec.

Advantage has also been taken of the shallow depth of water in constructing the abutments, which are each 242 feet in length, and consist of masonry of the same description as that on the piers which I am about to describe, and, from their being erected in such a small depth of water, their foundations do not require any extraordinary means for their construction.

The foundations, as you are aware, are fortunately on solid rock, in no place at a great depth below the summer level of the water in the river.

Various methods of constructing the foundations suggested themselves and were carefully considered, but, without deciding upon any particular method of proceeding, it was assumed that the *diving-bell*, or such modifications of it, on a larger scale, as have been recently employed with great success in situations not very dissimilar, would be the most expedient. The Contractors, however, or rather the Superintendent, Mr. Hodges, in conjunction with Mr. Ross, after much consideration on the spot, devised another system of laying the foundations, which was by means of floating "coffer-dams," so contrived that the usual difficulty in applying coffer-dams for rock foundations would be, it was hoped, in a great measure obviated. When in Montreal, I examined a model of this contrivance and quite approved of its application, without feeling certain that it would materially reduce the expense of construction below that of the system assumed to be adopted by Mr. Ross and myself in making the estimate. In approving of the method proposed by Mr. Hodges, I was actuated by the feeling that the Engineers would not be justified in controlling the Contractors in the adoption of such means as they might consider most economical to themselves, so long as the soundness and stability of the work were in no way affected.

This new method has been hitherto acted upon with such

new modifications as experience has suggested from time to time during the progress of the work, and although successfully, I learn from the Contractors that experience has proved the bed of the river to be far more irregular than was at first supposed—presenting, instead of tolerably uniform ledges of rock, large loose fragments which are strewed about, and cause much inconvenience and delay.

They are therefore necessitated to vary their mode of proceeding to meet these new circumstances; and it may be stated that all observations up to this time show the propriety, notwithstanding the difficulty with dams, of carrying the ashlar masonry of the piers down to the solid rock, and that any attempt at obtaining a permanent foundation by means of concrete confined in "caissons" would be utterly futile. However, if it were assumed to be practicable, there would be extreme danger in trusting such a superstructure of masonry upon concrete, confined in cast-iron caissons above the bed of the river. Indeed, considering the peculiarities of the situation and the facts which have been ascertained, this mode of forming foundations is the most inappropriate that can be suggested, as it involves so many contingencies, that to calculate the extreme expense would be utterly impossible.

These considerations lead me, therefore, to the conclusion, that the present design for the foundation is as economical as is compatible with complete security.

We are now brought to the question, as to whether the upper masonry is of a more expensive description than necessary, or whether it can be reduced in quality. This question is exceedingly important, since the cost of the masonry constitutes upwards of 50 per cent. of the total estimated cost of the bridge and approaches. The amount of the item of expenditure for the masonry is clearly dependent upon the number of piers, which is again regulated by the spans between them.

The width of the openings in bridges is frequently influenced, and sometimes absolutely governed, by peculiarities of site. In the present case, however, the spans, with the exception of the middle one, are decided by a comparison with the cost of the piers; for it is evident that so soon as the increased expense in the roadway, by enlarging the spans, balances the economy pro-

duced by lessening the number of piers, any further increase of span would be wasteful.

Calculations, based upon this principle of reasoning, coupled to some extent with considerations based upon the advantages to be derived from having all the tubes as nearly alike as possible, have proved that the spans which have been adopted in the present design for all the side openings, viz. 242 feet, have produced the greatest economy. The centre span has been made 330 feet, not only for the purpose of giving every possible facility for the navigation, but because that span is very nearly the width of the centre and principal deep channel of the stream.

The correctness of the result of these calculations obviously depends upon the assumption, that the roadway is not more costly than absolutely necessary; for if the comparison be made with a roadway estimated to cost less than the tubular one in the design, then the most economical span for the side openings would have come larger than 242f eet, and the amount of masonry might have been reduced below what is now intended. In considering the quantity of masonry in the design, you must, therefore, take it for granted, for the moment, that the *tubular roadway* is the cheapest and best that could be adopted, and leave the proof of this fact to the sequel of these remarks.

It may perhaps appear to some in examining the design, that a saving might be effected, in the masonry, by abandoning the inclined planes which are added to the up-side of each pier, for the purpose of arresting the ice, and termed "ice-breakers."

In European rivers, and I believe in those of America also, these "ice-breakers" are usually placed a little way in advance of, or rather above, the piers of the bridges, with a view of saving them from injury by the ice shelving up above the level of (frequently on to) the roadway.

In the case of the Victoria bridge, the level of the roadway is far above that to which the ice ever reaches; and as the ordinary plan of "ice-breakers" composed of timber and stone would be much larger in bulk, though of a rougher character, than those which are now added to the piers, I have reason to believe that they would be equally costly, besides requiring constant annual reparation. It was therefore decided to make them a part of the structure itself, as is now being done.

To convey some idea of the magnitude of ordinary "ice-break-



ers" placed on the up-side of the pier, and to enable you to form some notion of their cost, I cannot do better than quote the following from the excellent report addressed to the Honorable John Young, by Mr. Thomas C. Keefer, whose experience in such matters, from long residence in the country, entitles his opinion as to the proper character of such works to confidence:

"The plan I have proposed contemplates the planting of very large "cribs" or wooden "shoes," covering an area of about one fourth of an acre each, and leaving a clear passage between them of about 240 feet,—a width which will allow ordinary rafts to float broadside between them. These "islands" of timber and stone, will have a rectangular *well* left open in the middle of their width, toward their lower ends, out of which will rise the solid masonry towers, supporting the weight of the superstructure, and resting on the rocky bed of the river. This enclosure of solid crib-work, all round the masonry, yet detached from it, will receive the shock, pressure, and grinding of the ice, and yield to a certain extent, by its elasticity, without communicating the shock to the masonry piers. These cribs, if damaged, can be repaired with facility, and, from their cohesive powers, will resist the action of the ice better than ordinary masonry. During construction, they will serve as coffer-dams, and, being formed of the cheapest materials, their value as service-ground or platforms for the use of machinery, the moving of scows, &c., during the erection of the works, will be at once appreciated. Their application to the sides of the piers is with particular reference to preventing the ice from reaching the spring of the arches, which will be the lowest and most exposed part of the superstructure, if wood be used."

In the first design for the Victoria bridge, "ice-breakers" very similar to the above described by Mr. Keefer were introduced; but subsequently the arrangement was changed, partly with a view of gaining the assistance of the whole weight of the bridge to resist the pressure of the ice, before it became fixed, and partly for the purpose of obviating the considerable annual outlay.

I have not data at hand to estimate correctly the cost of the ordinary "ice-breakers" as described; but I have little or no doubt, that, as I before stated, they would have required to have been large and substantial masses of stone and timber, which

in amount of cost would be scarcely less than, if not equal to, the inclined planes of masonry which have been added to the up side of the piers. On this point, however, as well as upon others in reference to some reduction in the quantity of masonry in the piers and abutments, I intend to address Mr. Ross, who being on the spot will be able to determine with more accuracy than I can the amount of actual saving which can be effected in the masonry.

It is now necessary for me to say a word or two upon the style of the workmanship. It consists simply of solid ashlar; and considering the severe pressure and abrasion to which it will be subjected by the grinding of the ice, and the excessively low temperature to which it will for months be periodically exposed, I am confident that it is not executed with more solidity than prudence absolutely demands; and considering the difference of the rates of wages in Canada and this country, I believe the price of the work will come out nearly the same as any similar work let (here) by competition.

The description and style of the masonry is precisely similar to that adopted in the Britannia Bridge; the material is the same, and the facility of obtaining it is not in any important degree dissimilar.

The next point to be discussed is the construction of the superstructure, or roadway; and here, owing to the misconception which seems to exist on this subject amongst some Engineers, I am compelled to enter somewhat into technical details in reference to the treatment and construction of beams.

The matter has already been debated before the Institution of Civil Engineers, at great length, arising out of a paper read by Mr. Barton on the construction of the bridge over the river Boyne, erected under the direction of Sir John Macneill.

In the design of this bridge the Engineer has adopted what is technically termed the "Trellis" system of beam or girder, for the avowed purpose of saving material, as compared with the plain tubular system adopted in the Britannia, and now proposed for the Victoria Bridge.

It has been already stated that the design and the cost of masonry materially depend upon the comparative expense which may be incurred in the construction of the Roadway, since the spans or openings adopted are really governed by this item in the



estimate. It is, therefore, doubly necessary that this part of the proposed design should be analyzed with care.

Notwithstanding the discussion which took place at the Institution of Civil Engineers, as to the comparative merits of constructing beams in almost every variety of detail, it certainly appears, as far as I am able to form a judgment, that much error still prevails regarding the simple principles that should, and indeed must govern the arrangement of every beam-bridge.

The tubular system is openly declared by some to be a wasteful expenditure of material for a given strength;—in short, that, in the scale of comparative merit, it stands at the lowest point. This, if it were the fact, would not be extraordinary, since it was the first proposed for carrying railways over spans never before deemed practicable; but in the following remarks I hope to convince you, in the simplest manner, that (except in particular cases) whilst it is not a more costly method of construction, it is the most efficacious one that has hitherto been devised.

At present there may be regarded as existing three methods of constructing wrought-iron girders or beams for railway purposes.

First.—The *Tubular Girder*, or what is sometimes called the *Box-Girder*, when employed for small spans, with which may also be named the *Single-ribbed girder*,—the whole belonging to the class known as "*Boiler-plate*" girders.

Second.—The *Trellis-Girder*, which is simply a substitution of iron bars for the wood in the trellis-bridges, which have been so successfully employed in the United States, where wood is cheap and iron is dear.

Third.—The *Single triangle girder*, recently called "Warren," from a patent having been obtained for it by a gentleman of that name.

Now in calculating the strength of these different classes of girders, one ruling principle appertains, and is common to all of them. Primarily and essentially the ultimate strength is considered to exist in the top and bottom,—the former being exposed to a compressive force by the action of the load, and the latter to a force of tension; therefore, whatever be the class or denomination of girders, they must all be alike in amount of

effective material in these members, if their spans and depths are the same, and they have to sustain the same amount of load.

On this point I believe there is no difference of opinion amongst those who have had to deal with the subject. Hence, then, the question of comparative merits, among the different classes of construction of beams or girders, is really narrowed to the method of connecting the top and bottom *webs*, so called. In the tubular system, this is effected by means of continuous plates riveted together; in the trellis girders, it is accomplished by the application of a trellis-work, composed of bars of iron forming struts and ties, more or less numerous, intersecting each other, and riveted at the intersections; and in the girders of the simple triangular, or "Warren" system, the connexion between the top and bottom is made with bars,—not intersecting each other, but forming a series of equilateral triangles. These bars are alternately struts and ties.

Now in the consideration of these different plans for connecting the top and bottom *webs* of a beam, there are two questions to be disposed of; one is, Which is the most economical? and the other, Which is the most effective mode of so doing? But while thus reducing the subject to simplicity, it is of the utmost importance to keep constantly in mind, that any saving that the one system may present over the other, is actually limited to a portion, or per centage, of a subordinate part of the total amount of the material employed.

In the case now under consideration, namely, that of the Victoria tubes, the total weight of the material between the bearings is 242 tons, which weight is disposed of in the following manner:—

Top of Tube,	tons 76	
Bottom of Tube,	92	
		158
Sides of Tube,		84
Total tons,		242

Assuming that the strain per square inch, in the top and bottom, is the same for every kind of beam,—say 4 tons of compression in the top, and 5 tons of tension in the bottom,—the only saving that can by any possibility be made to take place

being confined to the sides, must be a saving in that portion of the weight which is only about 34 per cent of the whole. How, therefore, can 70 per cent of saving be realized, as has been stated, out of the total weight, when the question resolves itself into a difference of opinion on a portion which is only 34 per cent of such weight?

I am tempted to reiterate here much that was said by several experienced Engineers on the subject, during the discussions already allude to, at the Institution of Civil Engineers; but the argument adduced on that occasion could only be rendered thoroughly intelligible by the assistance of diagrams of some complexity, and I think sufficient has been said to demonstrate, that no saving *of importance* can be made in the construction of the roadway of the Victoria Bridge, as it is now designed by the substitution of any other description of girder. Yet, lest this should be considered mere assertion, permit me to adduce one or two examples, where the close-sided tubular system, and the open-sided system, may be fairly brought into comparison with each other in actual practice.

The most remarkable parallel case which occurs to me, is the comparison of the Victoria tubes under consideration, with a triangular, or "Warren" bridge, which has been erected by Mr. Joseph Cubitt, over a branch of the river Trent, near Newark, on the Great Northern Railway.

The spans are very similar, and so are the depths. In calling your attention to the comparison, you must bear in mind that all possible skill and science were brought to bear upon every portion of the details of the Newark-Dyke Bridge in order to reduce the total weight and cost to a minimum.

The comparison stands thus:—

VICTORIA BRIDGE AS BEING ERECTED.

Span, 242 feet; weight, including bearings, 275 Tons for a length of 257 feet.

NEWARK-DYKE BRIDGE AS ERECTED.

Span, 240 feet; 6 inches; weight, including bearings, 392 Tons for a length of 254 feet.

Which shews a balance of 17 tons in favor of the Victoria tubes.

The Newark-Dyke Bridge is only 13 feet wide, while the Victoria tube is 16 feet, having a wider-guage railway passing through it.

This is a very important case, as the spans and the depths are all but identical, and it will therefore enable you to form a judgment upon that point which has caused so much controversy at the discussion alluded to. It is true that in the Newark-Dyke Bridge a large proportion of the weight is of cast-iron, a material I have frequently adopted in the parts of tubular bridges subject to compression only, but from its brittle character I should never recommend it for exportation, nor for the parts of a structure that are liable to a lateral blow.

It has been suggested that there is much convenience in the arrangement of the trellis, or "Warren" bridge, as it may be taken to pieces, and more conveniently and economically transported over-land than "Boiler-plates." This may be correct under some circumstances, but it cannot hold good for a work like the Victoria Bridge over the St. Lawrence.

I am aware that girders upon the "Warren" principle have been adopted in India, and I am not prepared to call in question the propriety of these applications in certain cases; but what I have been aiming at in these observations, is, to prove to you that no economy over the plain tube can be effected in the case of the Victoria Bridge. I may add, that it has sometimes been urged that the workmanship in trellis, or "Warren" girders, is of a less expensive character than that required in tubes. I am bound to confess my utter inability to understand such a statement; for, after many years of practical experience as a manufacturer of iron work of every description, I do not know any class of workmanship that bears so small a proportion to the value of the material as boiler-plate work. If there be any difference in the cost, it ought certainly be in favor of tubular beams.

Another example may be mentioned of a tubular beam, somewhat similar in dimensions to the last described, and one which is actually erected on a continuation of the same line of railway as that on which the Newark-Dyke Bridge is situated; namely, over the river Aire at Ferry Bridge. Although the similarity is not so great with this as with the Victoria tube, yet I believe it is sufficiently so to form another proof that the advantage is in favor of the solid side.

As before:

NEWARK-DYKE BRIDGE.
Span, 240 feet, 6 inches; weight, 292 tons.
FERRY BRIDGE.
Span, 225 feet; weight, 235 tons.

The difference between these weights is more than sufficient to compensate for the difference of span; besides which, in the Ferry bridge, made according to my designs and instructions, I was lavish in the thickness of the side-plates, and the bearings which are included in the above weight were stiffened by massive pillars of cast iron.

For a further example, let me compare the Boyne trellis bridge (held by some to be the most economical) with the present Victoria tubes.

The Boyne bridge has three spans, the centre one being 264 feet, and the height is 22½ feet. It is constructed for a double line of way, and is 24 feet wide. The total load, including the beam itself, the rolling load at two tons per foot, and platform rails, &c., amount to 930 tons, uniformly distributed.

The bridge is constructed upon the principle of "continuous beams," a term which signifies that it is not allowed to take a natural deflection due to its span; but being tied over the piers to the other girders, the effective central span is shortened to 174 feet. In fact, this *principle* changes the three spans into five spans. Now the effective area given for compression in this centre span is 113½ inches, which gives a strain for the 174 feet span of nearly 6 tons to the inch in comparison.

The Victoria tubes are so dissimilar in form and circumstances to the Boyne bridge, that it is a troublesome matter to reduce the two to a comparative state. However, the Victoria tubes are known to be 275 tons in weight, 242 feet in span, and of 19 feet average depth, the strain not being more than 4 tons per inch for compression, with a uniform load of 514 tons, which includes its own weight, sleepers and rails, and a rolling load of one ton per foot.

The Victoria Bridge has not been designed upon the principle of continuous beams, for practical reasons, including the circumstance of the steep gradient on each side of the centre span, and the great disturbance which would be caused by the accumulated expansion and contraction, of such a continuous system of iron-work, in a climate where the extremes of temperature

are so widely apart; otherwise the principle alluded to, was first developed in tubular beams, namely in the Britannia bridge.

But since we are only now discussing the merits of the sides, let the Boyne bridge be supposed to have sufficient area in its top to resist 4 tons per inch (the proper practical strain), and let the spans be not continuous. It will be found by calculation that the area required at top will be 364 inches, instead of 113¼ inches, and the weight of the span would be found by calculation to come out little short of 600 tons; whereas it is now 386 tons; and if we suppose the Victoria tube to carry a double line of *way* and 24 feet wide with a depth of 22½ feet, even if we double the size in quantity, the whole amount of weight will be certainly very little more than 500 tons for 242 feet span.

It will be necessary to conclude my remarks with some further observations relative to the comparisons under our notice, which are of vital importance in considering the design of such a bridge as that to be erected for the Grand Trunk Railway of Canada.

Independently of the comparative weights and cost, which I believe have been fairly placed before you, the comparative merits as regards efficiency have yet to be alluded to.

You may be aware, that, at the present time, theorists are quite at variance with each other as to the action of a load in straining a beam in the various points of its depth; and the fact is now known, that all the received formulæ for calculating the strength of a beam subjected to a transverse load require re-modelling; therefore, at present it is far beyond the power of the designers of *trellis* or *triangular* bridges to say with precision what the laws are which govern the strains and resistances in the sides of beams, or even of *simple solid beams;* yet one thing is certain, which is, that the sides of all these trellis or "Warren" bridges are useless except for the purpose of connecting the top and the bottom and keeping them in their proper position. They depend upon their connection with the top and bottom webs for their own support; and since they could not sustain their shape but collapsed immediately they were disconnected from these top and bottom members, it is evident that they add to the strain upon them, and consequently to that extent reduce the ultimate strength of the beams.

In the case of the Newark Dyke Bridge, when tested to a



strain of 6¾ tons to the inch, its deflection was 7 inches in the middle; and when tested with its calculated load of one ton per foot run, the deflection was 4⅜ inches. The deflection of the Victoria tubes by calculation will not be more, with the load of one ton per foot, than ⅛ inch; and we have had sufficient proof of the correctness of this calculation in existing examples. That of the Boyne bridge, with a uniform load of 530 tons, was ½, with the spans shortened in effect as described.

Many other bridges of similar spans to those above named have been constructed upon the "open-side," or "truss" principle, which are (in every sense of the word) *excellent* structures; but since no comparison of economy between them and the Victoria tubes has been offered, it would be improper to class them with those (already named) which have actually been put forward as examples of economy to a large extent over the tubular system.

As an argument in favor of the trellis beams, it has been stated that no formula has been used to value the sides of a plate beam for horizontal strains; and, therefore, since the sides are thrown away except for the office they perform in connecting the top and bottom webs, it is asked why should more material be placed in the sides than sufficient for that purpose. Now I admit that there is no formula for valuing the solid sides for strains, and that we only ascribe to them the value or use of connecting the top and the bottom; yet we are aware, that, from their continuity and solidity they, *are* of value to resist horizontal and many other strains, independently of the top and the bottom, by which they add very much to the stiffness of the beam and the fact of their containing more material than necessary to connect the top and bottom webs, is by no means fairly established.

It is also said that the "trellis" and "Warren" beams are usually made deeper in proportion to their span, than the tubes and therefore the strain being less, a less quantity of material is employed in the top and bottom webs. An important consideration should be named in reply to this,—which concerns all the classes of beams alluded to,—which is, that *any change of proportion in the figure of a beam changes the amount of strain caused by the load, and consequently changes the weight of the beam itself.* The resistance to horizontal strain in the above

classes of bridges depends upon the distances between their top and bottom webs. Such beams are said to vary in strength directly as their depths, and inversely as their spans. With regard to tubular beams, a practical rule has been established, which determines that the depth shall not be less than 1-15th of the span; but althongh this is the minimum depth given, there is no reason to consider it the maximum depth. Indeed, the tubular bridges just named are of a greater depth than that proportion would give; for instance, the depth of Ferry bridge is 1-11th of its span, and that of the Victoria tubes, next the centre opening, is 1-12th of the span. These proportions are, I believe, very similar to those that are actually adopted for Warren or trellis beams.

It is well known that the diagonal "struts" in these latter systems (when under pressure) deflect as if they themselves were beams; and any increase in the depth of the sides would be an increase of length in the diagonals; which in the "Warren" must be compensated by an increase in their sectional area; and in the trellis beam, if they are not increased in area, they must be in number, so as to make more intersections; therefore an increase in depth of the sides of these systems, would not only be a proportionate increase in their weight, but would be an increase per square foot of their surface. Now the sides of a tube (from their nature) may be increased in depth up to a reasonable practical limit without any increase in their thickness.

Having given you my views with respect to the comparative merits of the different kinds of roadway consisting of "beams" that may be adopted in the Victoria bridge, I now proceed to draw your attention to the adaptation of the "suspension" principle, similar to that of the bridge which has been completed within the last few months by Mr. Roebling, over the Niagara River, near the Great "Falls."

You are aware that during my last visit to Canada I examined this remarkable work, and made myself acquainted with its general details; since then Mr. Roebling has kindly forwarded to me a copy of his last report, dated May, 1855, in which all the important facts connected with the structure, as well as the results which have been produced since its opening for the passage of railway trains, are carefully and clearly set forth.

No one can study the statements contained in that report without admiring the great skill which has been displayed throughout in the design; neither can any one who has seen the locality fail to appreciate the fitness of the structure for the singular combination of difficulties which are presented.

Your Engineer, Mr. Alexander Ross, has personally examined the Niagara bridge since its opening, with the view of instituting, as far as is practicable, a comparison between that kind of structure and the one proposed for the Victoria Bridge; and as he has since communicated to me by letter the general conclusions at which he has arrived, I think I cannot do better than convey them to you in his own words, which are subjoined below:—

"I find from various sources that considerable pains have been taken to produce an impression in England in favor of a Suspension Bridge in place of that we are engaged in constructing across the St. Lawrence at this place. This idea, no doubt, has arisen from the success of the Niagara Suspension Bridge, lately finished by Mr. Roebling, and now in use by the Great Western Railway Company, as the connecting link between their lines on each side the St. Lawrence, about two miles below the Great 'Falls,' of the situation and particulars of which you will no doubt have some recollection. I visited the spot lately, and found Mr. Roebling there, who gave me every facility I could desire for my objects. Of his last report on the completion of the work, he also gave me a copy, which you will receive with this: I have marked the points which contain the substance of his statement. I also enclose an engraved sketch of the structure. Mr. Roebling has succeeded in accomplishing all he had undertaken, viz. safely to pass over railway trains at a speed not exceeding 5 miles an hour; this speed, however, is not practised,—the time occupied in passing over 800 feet is 3 minutes, which is equal to 3 miles an hour. The deflection is found to vary from 5 to 9 inches, depending on the extent of the load, and the largest load yet passed over is 326 tons of 2000 lbs. each, which caused a depression of 10 inches. A precaution has been taken to diminish the span from 800 to 700 feet, by building up, underneath the platform at each end, about 40 feet in length intervening between the towers and the face of the precipice upon which they stand; and struts have also been added, ex-

tending 10 feet further. The points involved in the consideration of this subject are, first, *sufficiency*, and second, *cost*. These are, in this particular case, soon disposed of. First, we have a structure which we dare not use at a higher speed than 3 miles an hour. In crossing the St. Lawrence at Montreal we should thus occupy three quarters of an hour; and allowing reasonable time for trains clearing and getting well out of each other's way, I consider that 20 trains in the 24 hours is the utmost we could accomplish. When our communication is completed across the St. Lawrence, there will be lines, [now existing, having their termini on the South shore,] which, with our own line, will require four or five times this accommodation. This is no exaggeration. Over the bridge in question, although opened only a few weeks, and the roads yet incomplete on either side, there are between 30 and 40 trains pass daily. The mixed application of timber and iron in connection with wire, renders it impossible to put up so large a work to answer the purposes required at Montreal; we must, therefore, construct it entirely of iron, omitting all perishable materials; and we are thus brought to consider the question of cost. In doing which, as regards the Victoria Bridge, I find that, dividing it under three heads, it stands as follows:—

First,—the approaches and abutments, which together extend to 3000 feet in length, amount in the estimate to £200,000

Second,—the masonry, forming the piers which occupy the intervening space of 7000 feet between the abutments, including all dams and appliances for their erection £800,000

Third,—the wrought-iron tubular superstructure, 7000 feet in length, which amounts to £400,000

(About £57 per lineal foot.)

Making a total of £1,400,000

"By substituting a Suspension Bridge the case would stand thus:—The approaches and abutments extending to 3,000 feet in length being common to both, more especially as these are now in an advanced state, may be stated as above at £200,000.

"The Masonry of the Victoria Bridge piers, range from 40 to 72 feet in height averaging 56 feet and these are 24 in number,



the number required for a suspension bridge admitting of spans of about 700 feet, would be 10, and these would extend to an average height of 125 feet.—These 10 piers, with the proportions due to their height and stability, would contain as much (probably more) masonry as is contained in the 24 piers designed for the Victoria Bridge, and the only item of saving, which would arise between these, would be the *lesser* number of dams that would be required for the suspension piers; but this I beg to say, is more than doubly balanced by the excess in masonry, and the additional cost entailed in the construction, at so greatly an increased a height. Next, as to the superstructure, which in the Victoria bridge costs £57 per lineal foot,—Mr. Roebling in his report, states the cost of his bridge to have been $400,000, which is equal to £80,000 sterling. Estimating his towers and anchor masonry at £20,000, which I believe is more than their due, we have £60,000 left for the superstructure, which for a length of 800 feet is equal to £75 per lineal foot, giving an excess of £18 per foot over the tubes, of which we have 7,000 feet in length.—By this data, we show an excess of nearly ten per cent in the suspension, as compared with the tubular principle, for the particular locality with which we have to deal, besides having a structure perishable in itself, on account of the nature of the materials; and to construct them entirely of iron, would involve an increase in the cost which no circumstance connected with our local, or any other, consideration at Montreal, would justify. We attain our ends by a much more economical structure, and, what is of still greater consequence, a more permanent one; and as Mr. Roebling says, no suspension bridge is safe without the appliances of stays from below, no stays of the kind referred to could be used in the Victoria bridge,—both on account of the navigation and the ice, either of which, coming in contact with them, would instantly destroy them. No security would he left against the storms and hurricanes so frequently occurring in this part of the world.

"No one, however, capable of forming a judgment upon the subject will doubt for one moment the propriety of adopting the suspended mode of structure for the particular place and object it is designed to serve at Niagara. A gorge 800 feet in width and 240 in depth, with a foaming cataract racing at a speed from

20 to 30 miles an hour, underneath, points out at once that the design is most eligible; and Mr. Roebling has succeeded in perfecting a work capable of passing over 10 or 12 trains an hour, if it should be required to do so. The end is attained by means the most applicable to the circumstances; these means however are only applicable where they can be used with economy, as in this instance."

My own sentiments are so fully conveyed in the above extract from Mr. Ross's letter, that I can add no further remark upon the subject, except that there appears to be a discrepancy in that part which relates to cost.

In dividing the £80,000 into items, Mr. Ross has deducted £20,000 for masonry, and left the residue £60,000 for the 800 feet of roadway. Now it appears evident that this amount should include the cost of the "land chains;" and assuming their value at about £15,000, there would be only £45,000 left for the 800 feet of roadway, thus reducing the cost per lineal foot to about that of the tube. But in the application of a suspension bridge for the St. Lawrence the item £15,000 for land chains, would of course have to be added to the cost of the 7000 feet of roadway, which would swell the amount per foot to a little over that of the tubes.

In all that has been said respecting the comparative merits of the different systems of roadway, you will perceive that a *complete wooden structure* has not been alluded to, because, in the first place, when the design for the Victoria Bridge was at first being considered, *wood* was deemed not sufficiently permanent; in the second place, the structures alluded to in the report, as being inferior to that now in progress, are proposed to be constructed of stone and iron work; and as a third reason, the construction of the tubular roadway is already so far advanced that any alteration, to the extent of abandoning *iron* and adopting *wood*, must involve monetary questions of so serious a nature as to render the subject beyond discussion, or even being thought of in this Report.

In conclusion, therefore, I have to state to you my deliberate opinion, that the present design now being carried out for the Victoria Bridge is the most suitable that can be adopted, taking all the circumstances into consideration, to which the question relates. In making this statement, I must ask you to bear in

mind, that I am not addressing you as an advocate for a tubular bridge, I am very desirous of calling your especial attention to this fact; for really much error prevails upon this point, through the impression that in every case I must appear as an advocate. No one is more aware than I am that such inflexible advocacy would amount to an absurdity.

I entirely concur in what Mr. Ross says respecting the propriety of applying the suspension principle of the passage across the Niagara gorge. No other system of bridge building yet devised, could cope with the large span of 800 feet, which was there absolutely called for, irrespective of the other difficulties alluded to.

Where such spans are demanded, no design of "beam" with which I am acquainted would be at all feasible. The tube, trellis, and triangular systems are impracticable, in a commercial sense, and even as a practical engineering question, the difficulties involved are all but insurmountable.

Over the St. Lawrence, we are, fortunately, not compelled to adopt very large spans; none so large in fact, as have been already accomplished by the simple "girder" system. It is under these circumstances that the suspension principle fails in my opinion to possess any decided advantage in point of expense; whilst it is certainly much inferior, as regards stability for railway purposes. The flexure of the Niagara Bridge, though really small, is sufficiently indicative of such a movement amongst the parts of the platform as cannot fail to augment where *wood* is employed, before a long time elapses.

I beg that this observation may be not considered as being made in the tone of disparagement: on the contrary, no one appreciates more than I do the skill and science displayed by Mr. Roebling in overcoming the striking engineering difficulties, by which he was surrounded. I only refer to the question of flexure in the platform as an unavoidable defect in the suspension principle, which, from the comparatively small spans that are available in the Victoria Bridge, may be entirely removed out of consideration.

I am, Gentleman,

Your obedient Servant,

(Signed,) ROB. STEPHENSON

CONTRACT FOR CONSTRUCTION OF THE VICTORIA BRIDGE OVER THE RIVER ST. LAWRENCE AT MONTREAL.

This Deed, made the 29th day of September, in the year of our Lord 1853, by and between the Grand Trunk Railway Company of Canada, of the first part; and William Jackson, of Birkenhead, and Samuel Morton Peto, Thomas Brassey, and Edward Ladd Betts, all of London, in England, Contractors, and doing business in Canada as Contractors, under the name and style of "Jackson, Peto, Brassey, & Betts," of the second part. Whereas, by an Act of the Parliament of the Province of Canada, passed in the sixteenth year of the reign of Her Majesty Queen Victoria, and intituled, "An Act to provide for the construction of a General Railway Bridge over the River Saint Lawrence, at or in the vicinity of the City of Montreal,' the Grand Trunk Railway Company of Canada are authorised and empowered to construct a Railway Bridge to be called and known as "The Victoria Bridge," across the River Saint Lawrence, from some point in the City or Parish of Montreal, above the point known as the "Rousseau Migeon," to some point in the Parish of Saint Antoine de Longueuil, or in the Parish of Laprarie de la Madeline

And whereas the said Grand Trunk Railway Company of Canada have determined to avail themselves of the powers and provisions in the said Act contained, and for that purpose have agreed with the said parties of the second part, that they, the said parties of the second part shall build and construct a Tubular Bridge across the River Saint Lawrence as aforesaid, and other works connected therewith, according to the plans, sections, and specifications hereinafter mentioned, and on the terms and within the time hereinafter mentioned.

And whereas the said parties hereto of the second part (hereinafter called the Contractors) have agreed with the said the Grand Trunk Railway Company of Canada, that they, the said Contractors, will make, build and construct the said tubular Bridge over the said River Saint Lawrence, at or near Montreal as aforesaid, and other works connected therewith as hereinafter

mentioned, according to the plans, sections, and specifications prepared and drawn by Robert Stephenson, of London, aforesaid Civil Engineer, M. P., and Alexander McKenzie Ross, of Montreal Civil Engineer, and either annexed hereto, or endorsed so as to refer to this Contract or Agreement upon the terms and conditions and for the price hereinafter mentioned. Now, therefore, this Deed witnesseth that it is hereby agreed by and between the said the Grand Trunk Railway Company of Canada, of the first part, and the said Contractors for themselves, their heirs, executors, and administrators, of the other part, in manner following: that is to say, that they, the said Contractors, will make, build, construct, and complete the said Tubular bridge over the River Saint Lawrence, and other works at or near Montreal as first above mentioned, at such point as shall be selected therefor by said Robert Stephenson and Alexander McKenzie Ross, with all the works necessarily or properly appurtenant thereto, in accordance with the said plans, sections, and specifications hereunto annexed or referring hereunto by endorsement or with any subsequent alteration or modification thereof as hereinafter mentioned, and in accordance with any additional plans, sections, or specifications as also hereinafter mentioned. The Bridge when completed to be in perfect repair, and of the best and most substantial character, and to be approved by said Robert Stephenson. That the Contractors shall, in case the payments hereinafter stipulated for are duly and punctually made, complete the said Tubular bridge and deliver it over to the Company ready for the laying the said Railway thereon, within eight years from the first day of July, 1853, subject however, to such extension of time, if required by the Contractors, as the said Robert Stephenson or such other Engineer to be appointed as hereinafter mentioned, shall fix and determine. And the said Company hereby undertake to apply for and obtain from the Provincial Parliament of Canada powers to extend the time for the completion of the bridge, in conformity with this clause.

That the said Robert Stephenson and Alexander McKenzie Ross shall have the location of the Bridge, and shall select and determine the point at which the Bridge shall cross the River, and the line or course in which it shall be made, the said selection and determination to be made in accordance with said Act

and the provisions thereof, and that the said Robert Stephenson and Alexander McKenzie Ross shall have liberty to make such alterations and modifications as they may jointly agree and think proper in all or any of the plans and sections and the specification, and may draw and prepare such further or additional plans and sections, specificatious, and detail plans of construction as they may jointly agree on and think proper.

That for and in consideration of the Contract sum of £1,400,000, sterling, the Contractors take upon themselves all ordinary risks and contingencies, including that of any extra expense by reason of any alteration or modification of the plans, sections, and specifications, not involving additional expenditure, and subject to the award of the said Robert Stephenson or such other Engineer, to be appointed as hereinafter mentioned, as to whether the Contractors are to be entitled to any and to what amount of extra payment up to the sum of £100,000, sterling, for any extraordinary circumstances or contingencies which may arise during the progress of the works, and which the said Robert Stephenson or such other Engineer as aforesaid, may consider entitles the Contractors to extra payment.

And the said "The Grand Trunk Railway Company of Canada," the parties of the first part, agree and covenant with the Contracters, their executors and administrators, that for the execution and construction by them of the same Tubular Bridge and other works, in accordance with and upon the terms and conditions of this Agreement, and of the plans, sections, and specifications before mentioned, that they, the said "The Grand Trunk Railway Company of Canada," will pay the said Contractors the said price or contract sum of £1,400,000, sterling, and also such additional sum not exceeding in the whole the sum of £100,000, sterling, as shall be awarded by the said Robert Stephenson or such other Engineer as aforesaid.

That the mode of payment shall be as follows :—

When and so soon as the said Robert Stephenson and Alexander McKenzie Ross, or either of them, shall certify that the Contractors have *bonâ fide* expended £50,000, sterling, in land, work, or materials, or plant brought upon or near the line of the proposed bridge, the Company shall pay to the Contractors in cash the amount so certified, less £10 per cent, which the Company shall retain in their hands as a reserve, and at the end of one



calendar month from the date of such certificate, the said Robert Stephenson and Alexander McKenzie Ross, or either of them, shall certify the value of the work done, and materials or plant brought from or near the line in such previous month, and the Company shall pay to the Contractors in cash the amount so certified, less 10 per cent, as before, and so on, at the end of each successive calendar month, until the amount reserved by and retained in the hands of the Company shall amount to the sum of £25,000, sterling, after which the whole of the amount certified shall be paid to the Contractors, without any reserve whatsoever; and upon the completion of the work and the giving of the final certificate of the said Robert Stephenson and Alexander McKenzie Ross of the completion of the said Bridge, the Company shall pay over to the Contractors in cash the amount so reserved and retained, and balance of any remaining in their hands of the said Contract sum.

That the Engineer of the Company shall, as soon as the site of the Bridge is fixed, agree with the Contractors upon a Schedule in sections on which the various advances and payments on account shall be made, which, when so agreed, shall become a part of this Contract.

And it is hereby declared and agreed, that in case of the death, refusal, or inability to act of the said Alexander McKenzie Ross, another Engineer shall from time to time be appointed by the said Robert Stephenson in place of, and who shall have all the powers of the said Alexander McKenzie Ross, and all acts, matters, and things which under this agreement then remained to be done by the said Robert Stephenson and Alexander McKenzie Ross shall be done by the said Robert Stephenson, and such other Engineer to be from time to time appointed by him; and in the event of the death, or refusal, or inability to act of the said Robert Stephenson, then all things then remaining to be done by the said Robert Stephenson shall be done by an eminent Civil Engineer, to be appointed by the President for the time being, of the institution of Civil Engineers, in England, upon the requisition of the parties hereto, or either of them.

That if any question or difference of opinion shall arise between the parties hereto as to this agreement, or any matter connected therewith or arising thereout in any way, every such question or difference of opinion, as often as any such shall arise, shall be

referred to the absolute decision of the said Robert Stephenson, as sole arbitrator, or in case of his death to the decision of an eminent Civil Engineer, to be from time to time appointed by the President of the Institution of Civil Engineers, in England, and the decision of the said Robert Stephenson, or of such Engineer so be so appointed, shall be binding and conclusive upon both parties as to the question or difference of opinion so referred to him.

That the parties hereto will make and enter into all such deeds and other instruments as may be necessary for giving effect to such reference, and will also enter into all deeds which may become necessary or expedient in fully carrying out the same.

That whenever in this Contract the words "the Contractors" are used they shall mean William Jackson, Samuel Morton Peto, Thomas Brassey, and Edward Ladd Betts, or the survivors or survivor of them, or three out of four of them, or two out of three of them, or the executors, administrators, or asisgnees of the survivor; and in the event of the bankruptcy or insolvency of any one or more of them, their or his assignees shall be excluded from all control or interest in this Contract; and when any act is to be done by the Contractors it shall be sufficient if done by or by the authority of the majority of them, or by the majority of the survivors of them in person, or acting under power of Attorney from each to the other, or by the survivor or survivors of them or by his executors, administrators, or assigns.

In witness whereof, the said "The Grand Trunk Railway Company of Canada," the parties of the first part, have hereunto affixed their common Seal, and the parties of the second part have hereunto set their hands and affixed their Seals, the day and year first herein above written.

Signed, sealed, and delivered (in duplicate), in presence of

WILLIAM JACKSON, [L S.]
S. M. PETO, [L S.]
THOMAS BRASSEY, [L S.]
EDWARD L. BETTS, [L S.]

The Seal of the Grand Trunk Railway Company of Canada, was hereunto affixed by me,

JOHN ROSS,
President.



Specification referred to in foregoing Contract.

This structure, as designed, extends to a length of nine thousand four hundred and thirty-seven feet from one extreme end to the other, and consists of twenty-five openings, spanned by wrought-iron beams, resting upon solid pieces of limestone masonry, and at an elevation in the centre opening (which is three hundred and thirty feet wide) of sixty feet clear height above the summer water level, from thence descending at the rate of one in one hundred and thirty to either end, which terminates at a level twenty-four feet below that of the centre.

The Contract comprehends the supply of all materials, the construction and completion of that portion extending from the shores of the river to the abutments of the Bridge, consisting principally of stone embankments.

The construction and completion of twenty-four piers or towers and two abutments of limestone masonry, and the construction and completion of the wrought iron superstructure, extending to a length of six thousand five hundred and seventy-six feet. Also, the construction and completion of the permanent way extending the whole length of the Contract.

The raising and final erection on the piers, the painting and the entire completion of all the iron, wood, and stone work described in the following specifications and accompanying drawings, together with all works incidental to such construction and completion, and which may not be particularly described.

All temporary erections in staging machinery, floating craft, and every appliance requisite for carrying on the works in the most approved and systematic manner to be provided; and during any operations connected with the execution of the works, which may impede or interfere with the navigation of the river, or which operations may be interfered with by anything passing on the river, the Contractors shall adopt all such precautions by lights and signals, or by the use of boats, hulks, booms, or fenders, or by any other means for the protection of the public using the river, or of the works of the Bridge, as shall be reasonably necessary, as also for securing the works while in progress from any injury they may at any time sustain from vessels navigating the St. Lawrence, or from storms or any other cause likely to damage the works.

And any damage or injury which may at any time be sustained from any cause whatever, to be at the risk of the Contractors, who will be bound to make good the same at their own cost, save and except such damage as may arise from tempest or any act of God, not to be provided against by a reasonable amount of human caution.

The whole of the works herein referred to, as well as the mode of execution, is to be under the entire control, supervision and direction, and is to be constructed to the entire satisfaction of the Engineers, who shall have full power to alter, enlarge, or diminish the forms, dimensions, positions, or quantities of any of the works not involving extra expenditure in the whole; and if during their progress any imperfection shall appear in any part of the works, it shall be immediately repaired and made good under the direction and to the satisfaction of the Engineers.

The whole of the works of the Contract to be completed within the period of eight years from the first day of July, one thousand eight hundred and fifty-three.

Approaches.—One thousand three hundred and forty-four feet at the north, and one thousand and thirty-three feet at the south end, are to be constructed of solid embankments composed of stone, to the average height of thirty feet above summer water level, and of the width of thirty feet on the upper surface, formed with a slope of one to one on the down-stream side, and a slope of two and a half to one on the upper side,—as shown on the drawings detailing in this portion of the work.

All loose materials and debris of every description being first removed and cleared from the surface of the rock forming the bed of the River upon which the structure is founded.

The masonry forming the approaches and abutments to the Bridge erected on the above, is to be composed of Limestone Ashlar in large blocks.

All the beds and vertical joints to be square-dressed in the most efficient and workmanlike manner. The external face of the masonry to be rough, and without any pick or tool marks of any kind. The natural quarry-face, in all cases, to be preserved, excepting in the string-courses and copings, which are to be fair pick-dressed throughout, and neatly jointed and weathered where required, and a tool-draft eight inches wide on each quoin.

The masonry of the piers of the Bridge being built in eight to twelve feet depth of water, must necessarily be set by means of the diving-bell or otherwise, as directed; for the employment of which proper means and appliances must be provided, and on a scale commensurate with the magnitude of the undertaking and the rate of progress required.

The masonry of the piers to be constructed of the form and dimensions set forth in the drawings detailing the same. When each of the piers respectively has been brought up to the surface water-level, all irregularities in the upper bed of the masonry are to be rectified, and prepared level and square for the succeeding course.

The cut-waters and the sides of the piers, to the height of thirty-two feet above summer water level, are to be dressed smooth on the face, so as to present the least obstruction to the ice or any other masses floating down the stream; and above this level the face of the masonry is to be left rough as from the quarry, with a tool-draft eight inches wide on each quoin.

The horizontal and external vertical beds and joints, in all cases, to be smooth, dressed and truly fitted in every particular, so as to ensure the most solid and compact mass.

Dowels to be introduced wherever directed in the blocks forming the cut-water to the piers, and iron ties and holding-down bolts to be also used as may be directed, as further precaution for securing this part of the masonry.

The blocks of limestone to be of the largest dimensions obtainable in the quarries, commencing with the thickest at the foundations, and gradually diminishing as the masonry advances to the top. Recesses to be left in the piers, as shewn upon the drawings, for the purpose of facilitating the fixing of the iron superstructure. The face of the recesses to be smooth dressed, so as to present an even and uniform surface. The mortar used to be of the best hydraulic lime, and mixed in a rolling mill, with such proportion of clean, sharp sand as may be found to produce the most effective cement. The bed of the River being formed of flat bedded limestone of generally uniform surface, a secure foundation is readily obtained; but in some instances a lift of from two to three feet may occur within the area of a Pier foundation, and in such case these inequalities are, by means of blocks of masonry filling the same, to be brought to a general uniform

evel, and each course thereafter must be of a uniform thickness hroughout, and the blocks made to fit so close one to the other s to insure the most perfect and secure description of masonry, or which purpose every appliance in diving-bell and other aparatus must be amply provided, and also superintended by ell-known experienced workmen, previously accustomed, by ractical training, to operations of the kind required. The maonry of any Pier, once commenced, must be proceeded with ninterruptedly, until it reaches the height of thirty feet above ummer water-level, and as much more as may be deemed neecesary to insure its safety throughout the winter season, when ll building operations must necessarily be suspended, and durng which time all unfinished works must be protected from the reather by such precautions as are usual and proper for effectng such purpose. Any part of the Masonry suffering from rinter exposure to be restored properly and made good in a atisfactory manner.

Iron Work.—The superstructure of the Bridge is to be composed of wrought-iron beams, of the form and dimensions and arious thicknesses of metal indicated upon the drawings. The oles to be punched with proper machinery adapted to such purposes; and the rivetting also, as far as practicable, to be performed by proper machinery, so much of the revetting as must ecessarily be performed by hand to be executed in the most ffective manner. All the iron to be of the best boiler-plate ron capable of bearing a tensible strain of twenty tons per quare inch; any plate which may be found not to come up to his standard shall be rejected. All the plates shall be rolled erfectly level, and all buckle removed previous to rivetting hem; they shall everywhere gauge the thickness or correspond n weight to the thickness specified; to be truly sheared so as o form perfect butt joints. The angle and T irons shall be rolled f the section shewn in the drawings; all the rivets to be of the ery best iron used for such purposes, commonly called Scrap ron, and of the dimensions set forth in the drawing. All the ivet holes to be truly punched and correspond fairly with each ther and where required to be rimered previous to rivetting. ll the plates to be well brushed over with a mixture of linseed nd boiled oil in equal quantities; such process to take place hile the plates are hot, and after having been passed through

the roller for the last time. On no account is any plate, angle, or T iron to be used without having previously received this coat, nor are they to be used in a rusty or dirty state. Cast-iron bed plates to be provided for the friction rollers, to be furnished with wrought-iron frames and turned friction rollers, of the dimensions and forms described upon the drawings. Lintels of wrought or cast iron as may be hereafter directed, to be provided for bearing the tubes and covering the recesses in the masonry of the Piers, for facilitating the construction and lifting of the tubes. The timber, iron rails, and other fastenings required to complete the permanent way, to be provided and fixed as shewn in the drawings. Timber, wheresoever used in bedding the tubes, or in the roadway sills, is to be creosoted under pressure, after it has been converted. All the iron work of the tubes to be properly stopped and painted, inside and out, in three coats of patent white zinc paint. All surfaces that have to be rivetted in contact with each other shall be well painted before being so rivetted.

The Engineers, or any person appointed by them for the purpose, shall have free access at all times to the works where the manufacture of any of the materials required in this Contract shall be carried on, for the purpose of inspecting and properly testing, by any means he may think proper, all or any of such materials and workmanship, and the strength and quality of any manufactured parts of the work. All the materials and workmanship, as well as the mode of constructing and erecting, shall be such as the Engineers may approve of.

The drawings and specifications are intended to give a general description of the work, and to define the quantity, quality, and character of the same, and the mode in which it is to be carried on and completed; but many details which may arise in the execution must unavoidably be omitted, and some be erroneously described. Further drawings and directions will from time to time be given with reference to some parts, with the object of securing the best materials and workmanship, and the most perfect construction of every part of the Bridge, to be formed and completed according to the general design above described and shewn in the drawings attached. The Contractors to provide copies of the drawings and specifications for their own use, and to set out the work and take the necessary meas-



urements and levels, and to make all such working drawings and drawings of details as may be necessary for the execution of all the works ordered from general drawings and directions furnished originally, or from time to time by the Engineers.

Free use of the Province Lands to be given for the construction of the Bridge, and also for getting timber, stone, or other materials, for the works, and the full powers of the Company to be put in force for the benefit of the Contractors when required.

THE LEADING DIMENSIONS OF THE BRIDGE ARE AS FOLLOWS :—

		Feet.	Inches.
No—24	Openings or Spans, of 242 feet each.....	5,808	0
1	Centre do	330	0
2	Centre Piers, of 27 feet each.....	54	0
2	Large do of 25 do	50	0
2	do do, of 23 do	46	0
2	Small Piers, of 17 feet 8 inches each	35	4
2	do do of 17 do 4 do	34	8
2	do do of 17 do 0 do	34	0
2	do do of 16 do 4 do	32	8
2	do do of 16 do 0 do	32	0
2	do do of 15 do 8 do	31	4
2	do do of 15 do 0 do	30	0
2	do do of 14 do 8 do	29	4
2	do do of 14 do 4 do	28	8
2	Abutments, of 242 do 0 do	484	0
2	Approaches { 1344 do 0 do / 1033 do 0 do }	2,377	0
	Total length.....	9,437	0

Depth of Tube at abutments, seventeen feet, increasing to twenty-two feet in the middle.

Clear height above summer water-level, sixty feet in the middle, falling at the rate of one in one hundred and thirty towards the ends.

The following is a portion of the Report of the English Engineers who came out to examine the Victoria Bridge, at the request of Mr. Stevenson, prior to its opening for traffic:—

MONTREAL, 17th Dec., 1859.

To the Chairman and Directors of the Grand Trunk Railway Company of Canada, London.

GENTLEMEN,—As you may be aware, the Victoria Bridge was designed to sustain practically a load of one ton per foot run of its entire length, which load, added to the weight of the tubes themselves, it was intended should cause a horizontal tensile strain of five tons per square inch, and a compressive strain of four tons per square inch; and the load applied as a test was as near the above load as could possibly be provided. For the purpose of registering the deflections of the various tubes, a steel wire extending throughout the entire length of the bridge was strained as tightly as possible, being supported at every bearing of the tubes over pulleys with heavy weights attached, so as to keep an equal amount of tension upon it.

This steel wire formed the datum line, from which all the deflections were measured and marked on slips of card attached to vertical staves which were fixed up at various points along the tube. The train forming the testing load was sufficiently long to cover a pair of tubes from end to end, and it was first run on to one tube when observations were registered both in that tube and the adjoining empty one also, which was of course affected owing to its connection with the loaded tube.

As the effect produced was the same in all the ordinary pairs of tubes, it will only be necessary to give you the observations taken in one pair, which were as follows:—

While the load was in the first tube only, the deflection of that tube in the middle was seven-eighths of an inch, and the adjoining empty one was lifted in the middle three-eighths of an inch. The load then being placed over both tubes the deflection was the same in each, and was three-fourths of an inch in the middle; and when the load was run on to the second tube only, the effect on the two tubes was similar to that in the first experiment.

We next tested the large central span, which is quite unconnected with any other tube, and with the load extending from

end to end, caused a deflection of one and three-eighths of an inch in the middle.

In all the experiments, the tubes returned to their original position when the weights were removed.

The result of the test applied to the whole of the 24 tubes is highly satisfactory, inasmuch as the actual deflections were considerably within the calculated deflections, for such a load, according to formula, well known and generally made use of. We therefore consider the tubes excessively strong as regards the load they are designed to carry.

And we attribute this to the perfect manner in which they have been rivetted and fitted together, and the excellent quality of the iron of which they are composed.

In the 330 feet (central) tube, the smallness of the deflection is very remarkable, it being but little over five-eighths of the calculated deflection.

It is worthy of remark that it was a difficult matter to make up a train weighing the enormous load of one ton per foot run, and it was just as much as three large engines could do to propel it. Such a load surely never can pass through the bridge in the ordinary way of traffic.

The works required yet to be done to complete the Victoria Bridge are, the laying about 250 lineal feet of coping on the south approach, and fixing the iron caps to 22 piers.

And we beg to say, in conclusion, that when these small matters are completed, we should recommend the Board of Directors of the Grand Trunk Railway Company to accept the Victoria Bridge from the hands of Messrs. Peto, Brassey, and Betts, the Contractors, as being completed, satisfactorily, and according to the true spirit and meaning of the contract.

We are, gentlemen, yours, &c.,

(Signed,) J. B. BRUCE,
B. P. STOCKMAN.

REPORT OF MR. A. M. ROSS.

Having perused the foregoing report, I have much pleasure in adding, at the request of Mr. Bruce, that I was present and took part in the experiments undertaken with a view of testing the efficiency of the tubes, and that I concur in every detail as given in the report.

ALEX. M. ROSS.

A SHORT SKETCH

OF THE

LIVES OF THE CELEBRATED ENGINEERS

GEORGE AND ROBERT STEPHENSON.

The celebrated Lord Bacon has written, that biography may be said to follow, observe, and see individuals in all places, and in every instant of their lives, offering examples profitable to men in all conditions, and furnishing to the moralist matter for profound meditation.

Perhaps the history of two men connected by the nearest ties of blood, have never been recorded by the pen of a biographer, affording more matter for reflection and encouragement to genius than the lives of George and Robert Stephenson; commencing with the father, who started from the lowest step of the ladder to Fame, and ending with the son, on the very pinnacle of the Temple. Their names, too, have descended to posterity—unlike the great philosopher just mentioned, and other geniuses whose lives have been clouded with some dark spots—pure and spotless, and unsullied by any transaction, the world is aware of, that would cause the reader to sigh for the weakness of humanity.

As the lives of the two Stephensons would afford matter for volumes, all, therefore, that the reader can expect in a work of this description, limited to space, is a mere outline of their biographies; the lines without the lights and shadows to make a picture.

It is well known that the father of the late Robert Stephenson was the offspring of humble but honest parents. "Honest folks were they," says a neighbour in his rough Northumbrian

lect, "but they had little to go and come upon, and were e haudden doun in the world." They had six children, of om George, the second son, was born on the 9th June, 1781, a small clay-floored house in the village of Wylam, in which ed four families.

The poor man when wages were but 12s. a week, and bread war prices, can little afford to let his children run idle, and le George, at an early age, was engaged to take care of a cows, whose owner had the right of grazing them on the ggon roads, and to close the gates after the last waggon l passed; for this duty he received the recompence of two ice per day, As he grew in youth and his legs were long ough to straddle the furrows, we find him promoted, with dou- wages, to lead the horses at the plough, and other like work a farm.

But as the lad grew in strength he became ambitious of higher ngs, and longed to become an engine man, like his father. found employment in the colliery, and went through the eral grades of promotion, from picking stones out of the ls to driving the gin horse, at the rate of eight pence a day. fourteen he was taken by his father as assistant foreman.

The boy was a hard working lad and industrious, but, with a ural bashfulness, he feared that the owner of the colliery uld think him too small for the wages, and was in trepida- n often, lest he should meet him on his rounds.

George, however, soon out-grew all fears that his size would nd in the way of his promotion. In another year he grew be a stout bony lad, who could lift a heavier weight and fling ammer farther than any of his comrades. A laudable ambi- n, however, must have been a ruling passion in his breast, for e Saturday night when he went to receive his wages, he was d they had been raised to the full sum of 12 shillings a week. e youth's heart bounded within him; he felt that his industry l conduct had been appreciated, and he could not help exclaim- , as he left the foreman's office, "I am a made man for life!" other year passed away, bringing with it still further promo- n. He was now employed to keep the engine in order and to perintend its working. The steam engine soon became his t, and his leisure hours were spent in taking it apart, clean- and putting it up again. He soon understood it thoroughly,

and was rarely obliged to summon the colliery engineer to remedy any defect.

At eighteen George Stephenson was a full grown man, having the entire charge of a steam engine, and thoroughly master of all its details of construction. Education in those days was rarely to be obtained by the working classes, and up to this date young George Stephenson had never learned to read. The youth's heart, however, yearned after knowledge. A poor schoolmaster taught a school not far from the colliery. Thither George repaired three evenings in the week, after 12 hour's hard work, and in a year, at a cost of three pence per week, he had learned to read and to write his name. To reading and writing he determined to add arithmetic. His master set him sums on his slate to be wrought out at odd moments during the day. In the evening he took back the solutions for examination, and received new problems for the next day. In a short time he mastered the first four rules of Arithmetic, and reached the magic "Rule of Three," and beyond this the humble acquirements of his teacher did not extend.

But, although engaged 12 hours daily at his engine, devoting considerable time to the improvement of his mind from the slight education he had received from the humble schoolmaster, George still found leisure for other employments of a lighter kind, and, for the time, of a more profitable nature. We read of his following the trade of St. Crispin, as well as that of a tailor, and no doubt the trifling sums thus obtained were expended in books. By night, in his humble home,—he having become a married man at the age of twenty,—he tried, as best he might, to master the principles of mechanics. Like many other self-taught mechanics, he worked at *Perpetual Motion* and of course failed. Accident, however, put him in the way of turning his mechanical skill to advantage. Coming home one night, he saw a sad scene of confusion. The cottage chimney had been on fire; the neighbours had extinguished it by pouring down water, and the little room had been flooded. Worst of all, his fine eight-day clock stood still, the hand mutely pointing to the hour of the disaster. The mingled soot and steam had found its way within the case, and clogged and rusted the wheels and pinions. He was told that he must call

n the watchmaker to repair the damage. No, he would do it imself and save the money.

He tried—succeeded—and the clock was soon working away s merrily as ever. The fame of the exploit was bruited abroad, nd before long all the dilapidated time-keepers of the neighourhood were sent to him to be repaired.

In the third year of his marriage he met with a sad domestic ereavement in the loss of his wife. She left behind her one son, alled Robert, who afterwards became the first engineer in Engand, and the architect of the famous Britannia Bridge over the lenai Straits, and of the more celebrated Victoria Bridge, across he St. Lawrence.

Soon after the death of his wife, George Stephenson was inited to Scotland to take charge of an engine at a higher rate f wages. But his heart yearned for his old home and motherss boy, and he returned, after a year's absence, with twentyight pounds in his pocket.

He found himself sadly needed at home. His father, old obert, had been terribly scalded and rendered totally blind by n explosion in the colliery. With filial affection he devoted nore than one half of his savings to pay his father's debts, and stablished him in a cottage near his own, and was thence forard his sole and willing stay and support. The old man lived or many years blind, but cheerful to the last, and gladdened with the filial affection and the rising fortunes of his son.

The wars of the Great Napoleon, in which all Europe took a art, caused heavy taxes, high prices, and uncertain work, and ressed hard upon the working classes. England had 700,000 oldiers under arms, and the whole country was drained of its ardy sons. George Stephenson was drawn for the militia, and t cost him the remainder of his savings to purchase a substitute. appy for the world that it was so. The humble engineman as the last man that England could afford to lose.

At last the golden opportunity came; "there is a tide in the ffairs of man, which, if taken at the flow will lead on to forune." George Stephenson seized the advantage, and his after ife was one successful career. At the time we speak of he was hirty years of age.

Close by the pit where he worked a wealthy mining Company ad sunk a new pit and erected an engine to pump out the

water. The engine hissed and played, but there was something wrong. "She could not keep her jack head out of water." "All the engine men in the neighbourhood had tried, but were clean bet." For a whole twelvemonth George Stephenson had seen the smoke from the engine rising over the hill, but to every enquiry he received the same answer, "They were drowned out." He revolved the matter in his mind until he was satisfied that he had discovered the cause of failure, and one Saturday afternoon he walked over the hill to take a look at affairs.

"Weel, George," asked his friend Kit Keppel the "sinker," "what do you mak o' her? Do you think you could do anything to improve her?"

"Man, I could alter her and mak her draw; in a week's time, I could send you to the bottom."

This reply having been made known in the proper quarter, a fair trial was given, "and if successful," said the "viewer," "I'll make you a man for life." In three days after the engine had been taken down and the alterations made. On the fourth day it was set to work, and accomplished in two days what all the engineers in the neighbourhood could not get the engine to do in a twelvemonth.

For this he received ten pounds and a better situation. Not long after, the enginewright of the "Grand Allies" died, and the "viewer," true to his promise, appointed him to the vacant post with a salary of a hundred pounds a year.

We find him after this, being in better circumstances, engaged in curious mechanical contrivances. But among all his multifarious occupations, he lost no opportunity of carrying on his neglected education.

The son of a neighbouring farmer was well versed in arithmetic and knew something of mechanics and natural history. George soon learnt from him all that he knew.

He now placed his only son at the best school in the neighbourhood, and from him the father was not ashamed to take lessons. On Saturday the lad brought home books from the neighbouring library. The son inherited the talent of the father and was always desirous of reducing his scientific requirements to practice. He invested his pocket money in half a mile of copper wire, one end of which he attached to a kite string while the other was fastened to the garden palings, where his father's pony was

hitched. An opportune thunder-cloud passing, young Bob seized the occasion for verifying Franklin's famous experiments by bringing the wire in contact with the tail of the pony, whose plunging and kicking gave evidence of the success of the young enquirer.

The father scolded a little, but chuckled inwardly at this practical result of his son's scientific enquiries.

About this time fearful explosions of "fire-damp" were constantly occurring in the collieries. One day, in 1814, the deepest part of the colliery took fire. The miners were hurrying in terror to the shaft. As George Stephenson touched the bottom, he shouted "Stand back! Are there six men among you who have courage to follow me? If so, come, and we will put out the fire." His voice reassured the men, and they followed him. Brick and mortar were at hand. In a few minutes a wall was built up at the mouth of the burning shaft and the air excluded, by which means the fire was extinguished. But several miners were suffocated in the recesses of the mines.

"Can nothing be done to prevent such occurrences?" asked one, as he and Stephenson were searching for the dead bodies.

"I think there can," replied George.

"Then the sooner you start the better," was the reply, "for the price of coal-mining now is pitmen's lives."

Stephenson had for some time been engaged in making experiments upon coal-damp. These were now prosecuted with fresh zeal. In a few months he had devised his safety-lamp, and tested it in most dangerous situations. Sir Humphrey Davy produced his lamp about the same time. Both lamps were identical in principle, but neither inventor had any knowledge of the labors of the other. A controversy sprung up in consequence. A testimonial of £2000 was presented to Davy. The northern coal-owners raised half as much for Stephenson.

In the mean time the greater portion of his time was devoted to the subject of steam engines and railways, the intimate connection between which had begun slowly to dawn upon him.

Railways of rude construction had existed for centuries in the coal districts, where heavy loads had to be hauled for short distances on wooden rails covered with plate iron.

Engines had been made to run on common roads. In 1811, Mr. Blakinsop of Leeds made some improvements in locomo-

tives. One of them, the "Black Billy," ran upon the Wylan road, which passed the cottage in which Stephenson was born. It was a cumbrous affair, often taking six hours to go five miles, constantly getting out of order, and running off the track, so that horses had to be sent along with it to help it out of difficulty. No wonder that the workmen pronounced it a "perfect plague." No body at the time supposed that a locomotive with a smooth driving-wheel running upon a smooth rail could draw a load. It was assumed that the wheels would slip upon the rail and the machine consequently stand still. The driving-wheel was therefore fitted with teeth which worked in cogs in a rail laid by the side of the smooth rails upon which the carriage wheels ran.

George Stephenson had in the mean time been brooding over the subject of travelling engines, and declared he could make a better. He had by this time gained credit, as an ingenious machinist, and Lord Ravensworth, the proprietor of a coal mine, advanced money to enable him to make the experiment. This engine the colliery people called "Blutcher."

Blutcher was an improvement upon Black Billy, for he could draw a train at the rate of three miles an hour. Stephenson, also, by experiment, satisfied himself that a smooth wheel would hold upon a smooth rail, hence the toothed wheel and cogged rail were dispensed with.

Several improvements were afterwards made by Stephenson to this engine, by which its effective power was doubled. But although the success of the locomotive was thus established, years elapsed before it was adopted on another road.

Speculative men at last turned their attention towards railways. Foremost amongst these was a Mr. Pease, a wealthy quaker, who had, with some difficulty, procured the passage of a bill for constructing the Stockton and Darlington Railway, for the passage of waggons and other carriages by "men and horses *or otherwise*." This was about the year 1821.

Mr. Pease paid a visit to Killingworth to see Bluctcher, and was convinced of the engine being more economical than horses.

George Stephenson was employed by him to make a new survey of the road—for so far had his engineering studies brought him—and to construct the locomotives by which it was to be worked.

There was not at this time in England an establishment capable of making a locomotive. Stephenson proposed to set up such a factory.

The thousand pounds which he had received for his "Safety-Lamp," and an equal sum furnished by Mr. Pease, sufficed to set up the "Newcastle Engine Factory."

The Stockton and Darlington road was soon opened for traffic, and on this occasion one of Stephenson's locomotives drew a train weighing 90 tons, 8½ miles in 65 minutes. Thus far it was a decided success, though on a limited scale. But a new struggle and decided victory were in store for him.

For years the want of adequate communication between Manchester and Liverpool had been severely felt. Trade had outgrown the capacity of canals. It required more time to convey a bale of cotton from Liverpool to Manchester than now from New York to Liverpool.

The Manchester spindles stood still for want of the cotton which was piled up in the Liverpool warehouses. At length, some bold speculator suggested that railways could carry cotton and cloths as well as coals. So a plan was formed for a railway between Manchester and Liverpool; and the preliminary surveys were made, in spite of the determined opposition of the canal proprietors, and of the fox-hunting squires. The rural squires were told that the engines would kill pheasants and frighten foxes, so there would be an end of shooting and hunting. Farmers were assured that cows would not graze nor hens lay near a railroad; and timid old ladies were warned that their houses would be burned down by the sparks, and themselves poisoned by the pestilential smoke from the engines.

In fact, the country people of England were in as great dismay as a late M. P. P. of Canada, who solemnly declared in the House of Assembly, that the engines of the Grand Trunk Railway would frighten away all the milk from the cows. Every opposition that could possibly be offered to the construction of railroads in England was brought to bear against the scheme. George Stephenson was summoned before the committee of the House of Commons, and a dead set made against him by the lawyers. He was asked all sorts of relevant and irrelevant questions. Would any railroad bear a train of *forty tons* moving twelve miles an hour? Had he ever witnessed such a velocity?

Would not rails bend? Would not trains turn off the track? Would they not overturn when rounding a corner? If an engine going at the rate of twelve miles an hour should encounter a stray cow, wouldn't it be awkward? "Very awkward for the *coo*," replied Stephenson.

The philippics of Demosthenes or the orations of Cicero were naught compared with the eloquence brought to bear against railways; and more money was spent in lawsuits, in consequence, than would have built the whole line from London to Liverpool.

Even the famous Dr. Lardner, who subsequently immortalized himself by mathematically demonstrating that the Atlantic could never be profitably crossed by steam, brought his ponderous science to war against what he styled the "destruction of atmospheric air."

But the bill nevertheless passed, and the road was rapidly urged forward under the charge of George Stephenson, who was appointed chief engineer.

When the road was far advanced, a question arose whether it should be worked by stationary engines or by locomotives. Every scientific engineer was in favor of the former. Vallance affirmed that locomotives could never draw as fast as horses. Tredgold was sure that stationary engines would be safer and cheaper. Two distinguished engineers were deputed to look into the question. They did so, and reported that stationary engines would be in every way best.

Stephenson stood alone in favor of locomotives. He saw that railways and locomotives were inseparable parts of one great system. They were, as he phrased it, "husband and wife." He besought the directors at least to give the locomotives a fair trial before embarking in the cumbrous stationary system, and pledged himself to construct an engine which should meet all reasonable requirements. The main conditions were that the engine should not weigh more than six tons, and should be able to draw a load of twenty tons, ten miles an hour. A prize was offered to any party who should construct the best engine subject to those conditions. Stephenson's famous "Rocket" alone fulfilled the conditions. It was first: the rest were nowhere. It attained an average speed of fifteen miles an hour, and at times gained the hitherto unheard of velocity of twenty-nine miles. His honest friend Cropper, who had advocated the stationary system, was

astounded. "Now," he exclaimed, lifting up his hands,—"now is George Stephenson at last delivered."

The great battle had indeed been won by George Stephenson. The railway system had been inaugurated; a new implement had been put into the hands of civilization, the mightiest she had received since the invention of printing.

Here ends the epic interest of a life which was happy and prosperous to its close. He had attained well-deserved honors and fortune; and, finally, as age gathered around him, retired gracefully from active life, to that serene quiet which befits a man whose life's task has been worthily accomplished. Like many great men of science and literature, he was particularly fond of dumb animals, and took especial delight in his garden and conservatory. Nor was he indifferent to old pursuits. He was ever ready to lend a helping hand to inventors who deserved assistance. His heart was benevolent, and his purse was open to his old fellow-workmen whom age had left, as youth found them, in poverty.

He died on the 12th August, 1848, in the sixty-seventh year of his age.

THE LATE ROBERT STEPHENSON.

The early history of Robert Stephenson is intimately blended with that of his father, whom he ably assisted in the elaborate calculations which were necessary for his purposes. Indeed, through life the old man was accustomed to refer to his son for any subtle theoretical elucidation he might want, as well as for literary help on important occasions when he had to put his views on paper. But our space will not permit of our entering into the details of the life of this truly great man.

Robert Stephenson was born at Willington, Northumberland, on the 16th of November, 1803. His father, who had felt the want of an early education, resolved that his son should not suffer from the same cause, and accordingly, though at the time he could ill afford it, sent him to the school at Long Benton, and in 1814 placed him with Mr. Bruce at Newcastle. Robert soon displayed a decided inclination for mechanics and science; and, becoming a member of the Newcastle Literary and Philosophical

Institution, was enabled to take advantage of its library ; so that as the Saturday afternoons were spent with his father, the volume which he invariably took home with him, formed the subject of mutual instruction to father and son. Robert's assiduity attracted the attention of the Rev. Wm. Turner, one of the secretaries to the institution, who readily assisted him in his studies, and was, also, of much service to his father, with whom he soon after became acquainted. Under Mr. Bruce, Robert acquired the rudiments of a sound practical education, and, under his father's direction, was always ready to turn his acquirements to account. There still exists in the wall over the door of the cottage at Killingworth a sundial of their joint production, of which the father was always proud.

In 1818 Robert was taken from school and apprenticed to Mr .Nicholas Wood as acoal-viewer, a cting as under-viewer ; and he made himself thoroughly acquainted with the machinery and the processes of coal-mining. In 1820, however, his father being now somewhat richer, he was sent to Edinburgh University for a single session, where he attended the lectures of Dr. Hope on chemistry, those of Sir John Leslie on natural philosophy, and those of Professor Jamieson on geology and mineralogy. He returned home in the summer of 1821, having gained a mathematical prize, and acquired the most important knowledge of how best to proceed in his self-education. In 1822 he was apprenticed to his father, who had then commenced his locomotive manufactory at Newcastle, but, after two years' strict attention to the business, finding his health failing, he accepted, in 1824, a commission to examine the gold and silver mines of South America ; whence he was recalled by his father when the Liverpool and Manchester Railway was in progress, and he reached home in December, 1827. He took an active part in the discussion as to the use of locomotives on the line, and, in conjunction with Mr. Joseph Locke, wrote an able pamphlet on the subject. He also greatly assisted his father in the construction of the successful engine, which was entered in his name, though he himself ascribed the merit entirely to his father and Mr. Henry Booth, on whose suggestion the multitubular boiler was adopted.

Robert Stephenson's next employment was the execution of a branch from the Liverpool and Manchester Railway, near Warrington, now forming a portion of the Grand Junction Railway,

etween Birmingham and Liverpool. Before this branch was ompleted, he undertook the survey, and afterwards the contruction, of the Leicester and Swannington Railway; and on he completion of that work he commenced the survey of the ine of the London and Birmingham Railway, of which he was ltimately appointed engineer, and removed to London. Under is direction the first turf was cut at Chalk Farm on June 1, 834, and the line was opened on Sept. 15, 1838. Fully aware f the vital importance of obtaining good means of rapid transit, e still continued to devote much of his time to improvements n the locomotive engine, which were from time to time carried ut under his direction at the manufactory in Newcastle, which or some years was exclusively devoted to engines of that class, nd still supplies a larger number than any other factory in the ingdom, independently of many marine and stationary engines. His engagements on different lines of railway afterwards became very numerous; but he was more remarkable for the magnificent conceptions and the vastness of some of his successfully executed projects, such as the High-level Bridge over the Tyne at Newcastle, the viaduct (supposed to be the largest in the world) over the Tweed valley at Berwick, and the Britannia tubular bridge over the Menai Straits,—a form of bridge of which there had been previously no example, and to which, considering its length and the enormous weight it would have to sustain, the objections and the difficulties seemed almost insuperable .With the assistance, however, of Professor Hodgkinson, Mr. Edward Clark, and Mr. Fairbairn, in experiments on the best forms of the various portions of the structure, the difficulties were triumphantly overcome, and in less than four years the bridge was opened to the public, on March, 18, 1850.

Robert Stephenson was also employed in the construction of many foreign railways. He was consulted, with his father, as to the Belgian lines; also for a line in Norway between Christiania and Lake Miosen, for which he received the Grand Cross of the Order of St. Olaf from the King of Sweden; and, also, for one between Florence and Leghorn, about 60 miles in length. He visited Switzerland for the purpose of giving his opinions as to the best system of railway communication. He designed and constructed, for the Grand Trunk Railway of Canada, the Victoria tubular bridge over the St. Lawrence, near Montreal, on

the model of that over the Menai Straits. It is not long since he completed the railway between Alexandria and Cairo, a distance of one hundred and forty miles. On this line there are two tubular bridges,—one over the Damietta branch of the Nile, and the other over the large canal near Besket-al-Saba. The peculiarity of the structure is that the trains run on the outside upon the top of the tube, instead of inside. He was constructing an immense bridge across the Nile at Kaffre Azzayat, to replace the present steam-ferry, which was found to interfere too much with the rapid transit of passengers.

In addition to his railway labours, Robert Stephenson took a general interest in public affairs and in scientific investigations. In 1847 he was returned as member of Parliament in the Conservative interest, for Whitby, in Yorkshire, for which place he continued to sit until his death. He acted with great liberality to the Newcastle Literary and Philosophical Society, paying off in 1855 a debt amounting to £3000, in gratitude, as he expressed it, for the benefits he derived in early life from that establishment, and to enable it to be as practically useful to other young men. He most liberally placed at the disposal of Mr. Piazzi Smyth his yacht and crew to facilitate the interesting investigations undertaken by that gentleman at the Island of Teneriffe, and very valuable results have been obtained. He was an honorary but active member of the London Sanitary and Sewerage Commissions; a Fellow of the Royal Society; a member of the Institution of Civil Engineers since 1830, of which institution he was member of council during the years 1845 to 1847, vice-president during those from 1848 to 1855, and president during the years 1856 and 1857. He received a gold medal of honour from the French Exposition d'Industrie of 1855, and is said to have declined an offer of knighthood in Great Britain. He was also the author of a work "On the Locomotive Steam-engine," and another "On the Atmospheric Railway System," published in 4to. by Weale.

Mr. Stephenson left no family behind him. His wife (the daughter of Mr. Sanderson, insurance-broker, of Old Broad-street) died many years ago, and he remained a widower.

Robert Stephenson was beloved by all who knew him. He was a most generous man, without a particle of meaness in his nature. He was generous to his contemporaries and asso-

iates, and kind and forbearing to those who were under him. He was withal modest and retiring, avoiding ovations where he ould, and shunning publicity. Above all, he was an honest ıan. What was said of his father might with equal truth be ıid of him,—"He was one of nature's gentlemen."

The remains of this distinguished engineer were laid by the .de of Telford in the nave of Westminster Abbey. The obsequies ıay be said to have approached to the character of a public ıneral, from the spontaneity, numbers, and influence of the ıourners.

An immense crowd had assembled around the precincts of the ıbbey, where the hearse arrived at twelve o'clock. A procession ras then formed into the Abbey, led by the High Bailiff of Westıinster, whose silver staff of office was draped by a black scarf. 'he singing-boys folowed, their college caps draped in mourning. 'he singing-men wore black scarfs over their surplices. Then ame the senior Canons, and afterwards Canons Jennings, Cureon, and Repton. The Dean of Westminster and the Very Rev. 'henevix Trench, D.D., followed; and then came the Mayor and he Sheriff of Newcastle-upon-Tyne, in their scarlet robes. The offin was of highly-polished oak, profusely ornamented by gilt ails, escutcheons, &c., and covered by a heavy silk pall. The all-bearers on one side were the Marquis of Chandos, chairman of he London and North-Western Railway; Sir Roderick Murchion, F.R.S., President of the Royal Geographical Society; and Ir. George Carr Glyn, M.P., first chairman of the London and orth-Western Railway. The pall-bearers on the other side were Ir. Joseph Locke, M.P.; Mr. Beale, M.P., chairman of the Midand Railway; and Mr. George Rennie, C.E. Mr. Stephenson, he nephew of the deceased and his nearest male relative, folowed as chief mourner, and to him succeeded a long train of ıourners, in hatbands and scarfs, comprising the names best nown in the railway and engineering world. The great wesern door of Westminster Abbey is never open except at the ıneral of persons of Royal blood, or of those to whom the nation as decreed the honours of a public funeral. The procession, owever, went from the door in the south aisle to the western oor, and then directed itself along the whole length of the nave the choir. The choir commenced by singing "I am the Resurection and the Life" (Purcell), and, thus chanting, the proces-

sion passed within the screen to the choir, where the corpse for a short time was deposited. The sentences, "I know that my Redeemer liveth," and "We brought nothing into this world," were also chanted by the choir, accompanied by the organ. The 90th Psalm was then chanted to one of Purcell's chants. The Rev. Mr. Hayden, Precentor, then read the lesson, "Now is Christ risen from the dead;" after which the choir sang Handel's funeral anthem, "Where the ear heard him." The procession then re-formed, and returned to the grave; the clergy and choristers forming on the west, and the mourners on the south side. Several ladies belonging to Mr. Stephenson's family, in deep mourning, now joined the mourners. The choir hereupon sang the affecting passage, "Man that is born of woman." The dull sound of earth thrown upon the coffin was then heard, and the Dean uttered the impressive words, "Forasmuch as it hath pleased Almighty God to take unto himself the soul of our dear brother here departed, we commit his body to the ground; earth to earth, ashes to ashes, dust to dust."

The choir then sang with great sweetness, "Blessed are the dead which die in the Lord, for they rest from their labours," and Handel's beautiful anthem, "His body is buried in peace, but his spirit liveth for evermore." The Dean read the prayer, "We give Thee hearty thanks for that it hath pleased Thee to deliver this our brother out of this sinful world," and the service concluded with the Dead March in Saul by the organ.

The chief mourners then mounted the platform of earth and looked down into the shallow grave in which all that is mortal of Robert Stephenson reposes. The coffin bore the inscription, "Robert Stephenson, M.P., civil engineer, D.C.L. and F.R.S., born on the 16th of November, 1803; died on the 12th of October, 1859." The coffin of Mr. Telford was distinctly visible; and thus the two engineers who have spanned the Menai Straits, the one by the road and the other by the rail, slept side by side.

On the day of the funeral, the ships in the Thames lowered their flags in token of respect for the deceased; and at Gateshead, Newcastle, Shields, Sunderland, and Whitby, most of the places of business were closed in the afternoon. The ships carried their flags half-mast high, and muffled peals of bells rang from the church belfries.

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W. SHANLY,
General Manager.

July 1860.

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TABLE OF DISTANCES.

☞ **OBSERVE.—The Trains between Montreal, Toronto, and Quebec, are run by Montreal time; those between Toronto, London, and Sarnia, by Toronto time; and those between Portland and Island Pond, by Portland time.**

MAIN LINE.

UP TRAINS.		DOWN TRAINS.	
Total Miles.	STATIONS.	Total Miles.	STATIONS.
	MONTREAL		DETROIT
15	Pointe Claire	3	Detroit Junction
21	St. Anne's	20	Utica Plank
24	Vaudreuil	25	Mount Clemens
37	Coteau Landing	41	Beebe's Corner
54	Lancaster	62	Port Huron
60	Summerstown	63	Sarnia, Pt. Edward
68	Cornwall	94	Widder
77	Dickinson's Landing	111	Craigs
84	Aultsville	118	Lucan
92	Williamsburg		
99	Matilda	154	London
104	Edwardsburg	144	Thorndale
112	Prescott Junction		
113	Prescott	133	St. Mary's
125	Brockville	143	Stratford
129	Lyn	149	Shakespeare
137	Mallorytown	156	Hamburg
146	Lansdowne	159	Baden
155	Gananoque	162	Petersburgh
173	Kingston	168	Berlin
199	Napanee	173	Breslau
207	Tyendinaga	182	Guelph
213	Shannonville	190	Rockwood
220	Belleville	196	Acton
232	Trenton	202	Georgetown
242	Brighton	205	Norval
249	Colborne	210	Brampton
256	Grafton	216	Malton
263	Cobourg	223	Weston
271	Pope Hope	226½	Carlton
280	Newtonville	232	TORONTO
286	Newcastle		
290	Bowmanville		Don



GRAND TRUNK RAILWAY OF CANADA.

MAIN LINE.—*Continued.*

TRAINS.		DOWN TRAINS.
Oshawa	243	Scarboro'
Port Whitby	249	Port Union
Duffin's Creek	253	Frenchman's Bay
Frenchman'sBay	255	Duffin's Creek.
Port Union	261	Port Whitby
Scarboro'	265	Oshawa
Don	275	Bowmanville
	279	Newcastle
TORONTO	285	Newtonville
Carlton	294	Port Hope
Weston	302	Cobourg
Malton	309	Grafton
Brampton	316	Colborne
Norval	323	Brighton
Georgetown	334	Trenton
Acton West	345	Belleville
Rockwood	352	Shannonville
Guelph	358	Tyendinaga
Breslau	366	Napanee
Berlin	392	Kingston
Petersburgh	410	Gananoque
Baden	419	Lansdowne
Hamburgh	428	Mallorytown
Shakespeare	436	Lyn
Stratford	440	Brockville
St. Marys	452	Prescott
	453	Prescott Junction
Thorndale	461	Edwardsburg
London	466	Matilda
	473	Williamsburg
Lucan	481	Aultsville
Craigs	488	Dickinson's Landing
Widder	497	Cornwall
Sarnia	505	Summerstown
Port Huron	511	Lancaster
Beebe's Corner	531	Coteau Landing
Mt. Clemens	541	Vaudreuil
Utica Plank	544	St. Anne's
Detroit Junction	550	Pointe Claire
DETROIT	565	MONTREAL

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GRAND TRUNK RAILWAY OF CANADA.

MAIN LINE.—*Continued.*

DOWN TRAINS.		UP TRAINS.	
Distances in Miles.	STATIONS.	Distances in Miles.	STATIONS.
	Montreal		Portland
3	St. Lambert	5	Falmouth
18	St. Hilaire	11	Yarmouth
31	St. Hyacinthe	12	Yarmouth Junction
38	Britannia Mills	22	New Gloster
44	Upton	28	Danville Junction
50	Acton	37	Mechanic Falls
62	Durham	41	Oxford
73	Richmond	48	South Paris
83	Windsor	62	Bryant's Pond
91	Brompton Falls	70	Bethel
97	Sherbrooke	80	Giead
100	Lennoxville	85	Shelburne
107	Waterville	91	Gorham
111	Compton	97	Berlin Falls
119	Coaticook	103	Milan
127	Boundary Line	109	West Milan
144	Island Pond	122	Northumberland
159	North Stratford	134	North Stratford
171	Northumberland	149	Island Pond
184	West Milan	166	Boundary Line
190	Milan	174	Coaticook
195	Berlin Falls	182	Compton
202	Gorham	186	Waterville
208	Shelburne	193	Lennoxville
213	Gilead	196	Sherbrooke
223	Bethel	202	Brompton Falls
231	Bryant's Pond	210	Windsor
245	South Paris	221	Richmond
252	Oxford	231	Durham
257	Mechanic Falls	243	Acton
265	Danville Junction	249	Upton
271	New Gloster	255	Britannia Mills
281	Yarmouth Junction	262	St. Hyacinthe
282	Yarmouth	275	St. Hilaire
288	Falmouth	290	St. Lambert
293	Portland	293	Montreal

GRAND TRUNK RAILWAY OF CANADA.

MAIN LINE.—*Continued.*

QUEBEC AND RICHMOND DISTRICT.

DOWN TRAINS.		UP TRAINS.	
Total Miles.	STATIONS.	Total Miles.	STATIONS.
	Montreal		Point Levi
73	Richmond	8	Chaudiere Junction
85	Danville	9	Chaudiere
97	Warwick	15	Craig's Road
105	Arthabaska	20	Black River
114	Stanfold	29	Methot's Mills
120	Somerset	41	Becancour
128	Becancour	49	Somerset
140	Methots Mills	55	Stanfold
149	Black River	64	Arthabaska
154	Craig's Road	72	Warwick
160	Chaudiere	84	Danville
161	Chaudiere Junction	96	Richmond
169	Point Levi	169	Montreal

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		Point Levi			St. Paschal
9	17	St. Henry	10	10	R. Ouelle
8	25	St. Charles	7	23	St. Rochs
9	49	St. Thomas	39	39	L'Islet
14	63	L'Islet	14	53	St. Thomas
8	79	St. Rochs	23	76	St. Charles
6	92	R. Ouelle	9	84	St. Henry
39	101	St. Paschal	8	101	Point Levi

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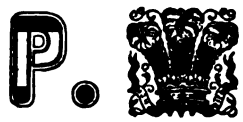
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TERMS CASH, AND ONLY ONE PRICE.

185 Notre Dame Street,

Montreal, July, 1860.

127

RICHARD HOLLAND,

182 Notre Dame Street,

OPPOSITE THE CATHEDRAL BLOCK,

IMPORTER OF

ENGLISH AND FRENCH

PAPER HANGINGS,

BERLIN WOOLS,

ENGLISH, FRENCH, AMERICAN, AND, GERMAN

FANCY GOODS.

The Subscriber imports his goods in such quantities as to enable him to avail himself of the *producers' lowest prices*, and by conducting his business on Cash principles, he can offer inducements both to Wholesale and Retail purchasers which would otherwise be out of his power.

He would call particular attention to his stock of PAPER HANGINGS which is the

LARGEST IN THE PROVINCE,

AND COMPRISES EVERY VARIETY.

RICHARD HOLLAND.

Montreal, July, 1860.
128

JOHN HENDERSON & CO.,

CRYSTAL BLOCK,

NOTRE DAME STREET,

MONTREAL.

ESTABLISHED IN 1832.

Keep constantly on hand a large and well assorted stock of

LADIES' & GENTS' FURS.

In HUDSON BAY SABLE, CANADA MINK, ROYAL ERMINE, CHINCHILLA STONE MARTIN, AFRICAN MONKEY, and every other description fashionable in Europe, United States or Canada.

For guarantee of excellence in workmanship we need only refer to the fact of our having been awarded Diplomas and Medals at

The London Exhibition in - - - 1851.
The Paris Exhibition in - - - 1855.
The Provincial Exhibition in - - 1850.
The Provincial Exhibition in - - 1853.

IN HATS AND CAPS

We keep a large and varied assortment manufactured and imported direct from the most celebrated makers in London, Paris and New York.

Always on hand a large and very extensive stock of

INDIAN CURIOSITIES,

In Bark and Bead work, Snowshoes, Moccasins, Toboggans, &c.

N.B.—J. H. & Co., will be happy at all times to exhibit their stock to the travelling public.

Every article sold at their establishment warranted as represented.

DONEGANA HOTEL,

Notre Dame Street,

MONTREAL.

G. F. POPE,

Takes leave to inform the Public that he has resumed the management of this much

FAVOURED HOTEL,

Established by him in 1850.

It is now furnished throughout anew with the most modern and costly furniture in a style second to no other Hotel on the Continent; and its pleasant situation in Notre Dame Street, between the Military Parade Ground (*Champ de Mars,*) the Government Garden on the one side, and Dalhousie Square and the Government and Departmental Offices and Public Buildings on the other, render it a desirable residence both for purposes of pleasure and business travel.

The Subscriber, in returning thanks for the unprecedented patronage always conferred on him, begs to assure the public that he will use every possible exertion to merit a continuance of the favors which it is his pride and pleasure to acknowledge as having been heretofore received from Foreign, American, and Provincial pleasure Travellers, from members of the Government and both Houses of the Legislature, Military and Departmental Officers, and the travelling community in general.

G. F. POPE.

Montreal, July, 1860.

130



ESTABLISHED 1818.

SAVAGE & LYMAN

Respectfully invite STRANGERS and OTHERS visiting the City to inspect their Stock of

GOLD AND SILVER WATCHES,

IN EVERY STYLE.

JEWELLERY

OF NEW AND CHOICE DESIGNS,

Especially got up in anticipation of the festivities in honor of His Royal Highness the

PRINCE OF WALES.

Fine Electro Plated Ware in all its varieties,—

MARBLE, MANTLE, AND WOOD HALL CLOCKS
LADIES' AND GENTS' DRESSING CASES
LEATHER RETICULES AND TRAVELLING BAGS
FINE FIELD AND OPERA GLASSES, AND TELESCOPES.

SILVER TEA AND COFFEE SETS,

JUGS, CUPS, and GOBLETS,
SALVERS,
FORKS,
SPOONS,
LADLES,

Of various Patterns of THEIR OWN Manufacture,

Stereoscopes, and views of all countries, especially Canada. Fine Cutlery, Razors, Scissors and a variety of Fancy Goods, forming the richest, and most extensive Stock in Canada.

—ALSO,—

The Prince of Wales "Medals"

In Silver, Bronze, and Metal.

CATHEDRAL BLOCK.
NOTRE DAME STREET.
131

JAMES PARKIN,

LACEMAN,

IMPORTER OF BRITISH AND FOREIGN

LACE & EMBROIDERY,

168 *NOTRE DAME STREET, MONTREAL.*

Direct importations—connexion with some of the First Houses in Europe—a long experience in the business, and the weekly arrival of Steamships to this Port, enable me to place before my customers the LARGEST & CHOICEST Assortment of

New and Fashionable Goods,

In this line to be found in Canada.

Every description of LACE and EMBROIDERY from the least expensive article of BRITISH MANUFACTURE, to the more costly and *recherché* of the CONTINENTAL FABRICS.

The attention of MILLINERS and MERCHANTS generally, is invited to the advantages of a Choice Assortment at all seasons, supplied direct from the FIRST MARKETS, and offered at the

LOWEST POSSIBLE ADVANCE FOR CASH.

WHOLESALE & RETAIL.

ESTABLISHED 1849.

Montreal, July, 1860.

132

M'MILLAN & CARSON,

MERCHANT TAILORS,

Manufacturers of Clothing,

AND

IMPORTERS OF WOOLLENS,

&c., &c.,

No 66 McGILL STREET,

Keep constantly on hand a carefully selected Stock of

Broad Cloths, Casimeres, Tweeds and Vestings.

From the well known character of their house, they flatter themselves that it is unnecessary to say anything about the price, style, or make of their garments.

They beg to call the special attention of Country Merchants to their stock of

READY MADE CLOTHING.

from the facilities they possess for the purchase of goods in the English market, as well as in Boston and this City, together with the great care and practical skill brought to bear on their manufacture, they are satisfied that they will compare favourably with any goods of the kind in Canada, and will be offered on

TERMS AS LIBERAL AS ANY HOUSE IN THE TRADE.

M'MILLAN & CARSON.

Montreal, July, 1860.

T. D. HOOD,

FIRST PRIZE PIANO FORTE



MANUFACTURER.

And Importer of the best American

PIANO-FORTES,

MELODEONS, &c., &c.

A SUPPLY OF THE LATEST POPULAR

SHEET MUSIC, MUSIC BOOKS, &C.,

Constantly on hand at his Warerooms,

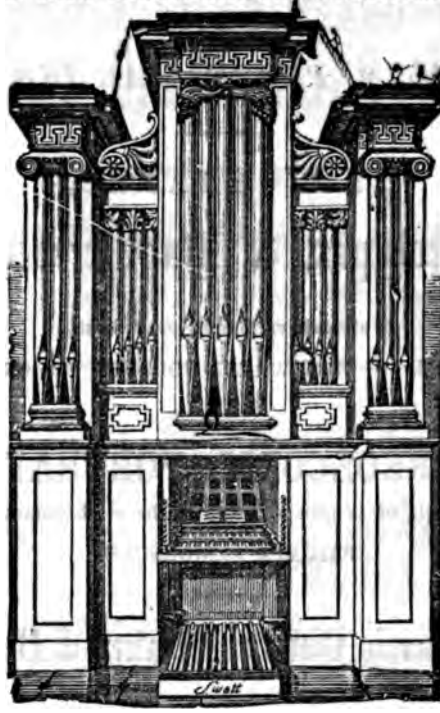
37 GREAT ST. JAMES STREET.

Montreal, July, 1860.

134

S. R. WARREN'S

rgan and Harmoneum Manufactory,



(Established in 1836,)

Corner of St. Joseph and St. Henry Streets,

MONTREAL,

Mr. Warren having recently enlarged his Establishment, is ow prepared to furnish every description of Church Organs. armoneums and Melodeons. FOR DURABILITY, PURITY OF ONE AND POWER, he is confident from over thirty years' perience that his Instruments can compete with those made in any other Manufactory, Foreign or Domestic.

Orders for Organs of the largest capacity filled with all omptness and dispatch.

EVERY INSTRUMENT FULLY WARRANTED.

Montreal, July, 1860. 135

DOANE'S

PHOTOGRAPHIC ESTABLISHMENT,

No. 2, PLACE D'ARMES.

PHOTOGRAPHS,

Ambrotypes, & Daguerreotypes,

in all their various styles of finish,

COLOURED IN OILS, WATER COLOURS, OR CRAYON.

STEREOSCOPIC PORTRAITS,

either single or in groups, taken at the establishment, or at

PRIVATE RESIDENCES.

Stereoscopic Views of Montreal & Vicinity.

Particular attention paid to taking Family Groups either for

STEREOSCOPE

OR

Cabinet Size Parlour Pictures.

NO. 2, PLACE D'ARMES, UP STAIRS.

Montreal, July, 1860.

136

SOAP, CANDLES,

AND

OILS.

John Mathewson & Son

Have constantly on hand, of their own Manufacture, an extensive stock of the different qualities of

COMMON SOAP.

STEAM REFINED PALE SOAP, unrivalled for family use.

LIVERPOOL SOAP, warranted superior to any of the imported brands.

TALLOW, WAX-WICK AND ADAMANTINE CANDLES.

Special attention is invited to their

Mason's Patent Sperm Oil,

Now so extensively used by Railroad and Steamboat Companies.

ALSO

No. 1 Lard	Oil.	Winter Pressed Whale	Oil.
Winter Pressed Sperm	"	Solar Sperm	"
" " Elephant	"	Machinery	"

STEAM SOAP, CANDLE & OIL WORKS,

INSPECTOR & COLLEGE STREETS,

MONTREAL.

ONLY DIRECT AND MAIL ROUTE

FROM MONTREAL

TO

BOSTON, NEW YORK, ALBANY,

TROY, SARATOGA, LAKE GEORGE, WHITE MOUNTAINS, &c.

VIA

MONTREAL AND CHAMPLAIN R. R.

TO ROUSES POINT,

Connecting twice each day with

The Splendid Lake Champlain Steamers

AND THE

Vermont Central, and Rutland and Burlington Railroads.

This Route is a delightful one for the Pleasure Tourist, or Business Traveller, combining comfort with ease, elegance, safety and dispatch; affording the quickest Lines to the Cities of NEW YORK and BOSTON, and the only Route to

LAKE GEORGE, SARATOGA, &c. &c.

Two trains daily between Montreal, and New York, and Boston Sleeping cars on night trains. No change. ☞ No other day line.

Connection at St. Johns 'with the Stanstead and Shefford Rail Road for Farnham, Granby, Waterloo, Lake Magog &c.

TIME

Montreal to	Boston,.....	13	hours
"	New York, by Railroad, ...	15	"
"	" Steamers & Railroad, ...	24	"
"	Lake George,.....	8	"
"	Saratoga, ...	11	"

Office of the Montreal and Champlain Railroad Company,

No. 64 Commissioners' Street,

Opposite the Quebec Steamboat Basin.

W. A. MERRY, Secretary.

GRAND EXCURSION

TO THE FAR-FAMED

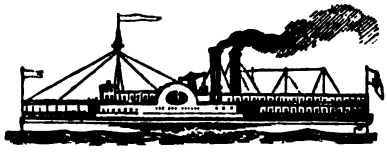
RIVER SAGUENAY!

AND

SEA-BATHING

AT

MURRAY BAY AND CACOUNA!



THE MAGNIFICENT IRON STEAMER

"MAGNET,"

Captain THOMAS HOWARD,

(Late of the Royal Mail Steamer "BANSHEE")

Will leave *Gillespie's Wharf*, QUEBEC, every TUESDAY and FRIDAY MORNING, during the Season, at EIGHT o'clock, for the

RIVER SAGUENAY to HA! HA! BAY,

CALLING AT

MURRAY BAY, RIVER DU LOUP & TADOUSAC.

☞ **NO EXPENSE OR INCONVENIENCE IN EXCHANGING BOATS AT QUEBEC; in every instance, the Steamers are brought alongside of each other.**

This Splendid Steamer, is built in water-tight compartments, of great strength, and equipped with every appliance for safety, and acknowledged to be one of the best Sea-Boats afloat. She is fitted up WITH LARGE FAMILY STATE-ROOMS, *most comfortably furnished, and in every respect* SECOND TO NONE ON THE CANADIAN WATERS.

Staterooms secured, and Tickets (giving ample time for *Sea-Bathing, Fishing and Hunting*) may be obtained, on application to C. F. MUCKLE at the Hotels, or at the Office, 40 Mc*Gill St.*

ALEX. MILLOY.

Montreal, July, 1860.

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MONTREAL

CARPET WAREHOUSE,

31 & 33 ST. FRANCOIS XAVIER STREET,

2 & 4 ST. SACRAMENT STREET.

R. CAMPBELL & CO.

Would invite to an examination of the beautiful designs they exhibit, both in

CARPETINGS AND OIL CLOTHS,

which they will cut to suit the dimensions of any apartments. The principal Manufacturers in England, Scotland, and the United States, are represented in their Stock. Every article connected with this particular business may be procured at their Warerooms on liberal terms.

WHOLESALE DRY GOODS.

The subscribers would invite the attention of merchants to their Stock of Fancy and Staple Dry Goods.

BRITISH, FRENCH, GERMAN, AMERICAN and CANADIAN Manufactures in Woollens, Silks, Linens and Cottons, constantly on hand. TERMS LIBERAL.

R. CAMPBELL & Co.,
31 & 33 St. François Xavier st.

Montreal, July, 1860.